POWER PLANT ENGINEERING

Established Over 28 Years

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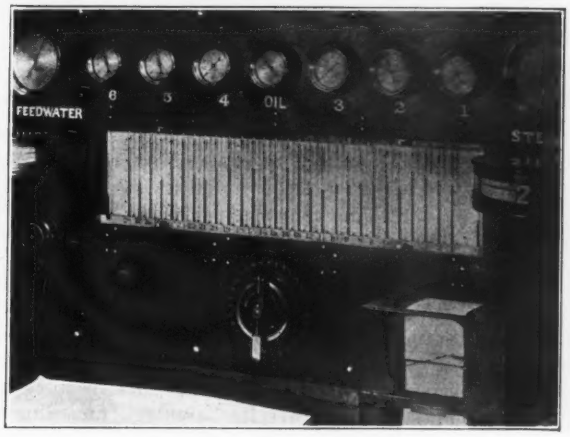
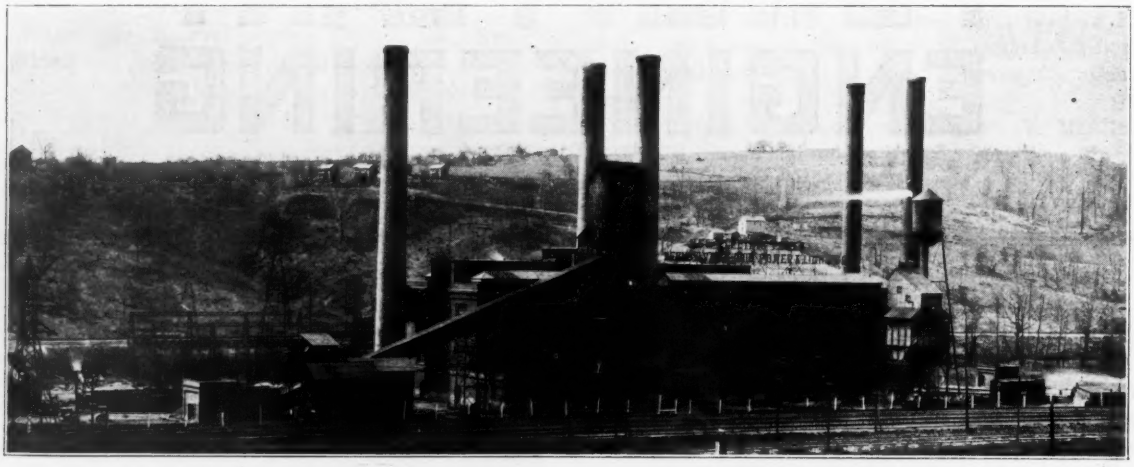


Coffee But No Cream

COFFEE is a mild stimulant to most people and when tempered with good cream forms one of our most delicious beverages. Whether the coffee used in the twenty-eight manometer tubes shown on the boiler control panel in the above photograph has any stimulating effect upon the draft we do not know, but it does help the operators considerably in reading the draft pressures. The brown liquid stands out clearly against the white background. This is only one of the many interesting features of the Lowellville Station of the Pennsylvania-Ohio Power & Light Co., described in this issue.

REBELLION against abuse is a trait which is usually accorded only to the animal kingdom but can there be a more dangerous rebel than the power plant steam boiler which is not treated with extreme deference and supplied with good water? With just the merest trace of oil in the feed water, for instance, the boiler puts in its objections by foaming, plastering the steam surface with scale, collecting balls of precipitates and throwing them against the plates over the fire to cause bags, contaminating the steam with moisture and dust that adheres to superheater tubes, turbine blades and condenser surfaces. On page 1244 Mr. Joos tells how to quell this rebellion against oil in the feed water.



Increasing Boiler Economy by Modern Methods

PURPOSE, KNOWLEDGE AND CO-OPERATION MUST BE HAD IF A CAMPAIGN FOR GREATER BOILER EFFICIENCY IS TO BE SUCCESSFUL. BY HARRY K. BLANNING

UNDER PRESSURE of a rapidly increasing power demand in the territory served by the Pennsylvania-Ohio Power & Light Co., extensive and intensive work has been going on for the last year at the company's 60,000-kw. Lowellville Station, at Lowellville, Ohio, with the aim of increasing the efficiency and by this increase to raise the power producing capacity without additional installation of boilers or generators. Results have been exceedingly gratifying and now after almost a full year of operation on a partially completed basis and 6 mo. on a fully completed basis, results are being shown which prove that the engineering and operating features are sound and fulfill the promise of modern operating methods.

In the boiler plant are nine Edge Moor boilers and 19 Babcock & Wilcox boilers, all of 6000 sq. ft. water heating surface. Eighteen of the boilers are fired by type AA4 Taylor stokers and ten by type AA6 Taylor stokers, all are 17 tuyeres long and seven retorts wide. Steam is superheated in Foster, and Babcock and Wilcox superheaters of 1110 sq. ft. and 950 sq. ft. of heating surface, respectively. Twenty-two boilers are equipped with the former and six with the latter. Steam is generated at 210 lb. gage and superheated to a total steam temperature of 510 deg. F.

Feed water is condensate with as much make-up as required, the make-up being treated by a lime-soda ash process in the Scaife water purification plant consisting of two 66,000-gal. reaction and settling tanks and two filter tanks with auxiliaries. Feed water is heated to 210 deg. F. in three Hoppes open heaters before entering the boilers. Boiler draft is furnished by five stacks, three concrete and two steel, all are 175 ft. above grates and 12 ft. in diameter; no induced draft fans being used. Flue gas breeching is all interconnected but the stacks can be localized to groups of boilers by closing dampers placed in the main breeching. The draft over the fire in the boiler furnaces is regulated by an Engineer Co. balanced draft system. The boilers are set in batteries of two, the two stokers under these boilers being driven by the same engine. The stoker drive consists of eight American Blower Co. and six Sturtevant engines of the usual design.

Forced draft is furnished by five Green Fuel Economizer Co. fans and one Buffalo Forge Co. fan, all turbine driven and with a total capacity of 600,000 cu. ft. of free air per min. at 6 in. static air pressure. The discharge from these fans enters one common duct 300 ft. long under the center of the boiler room floor and running its entire length. From this main duct two branch ducts each 28 in. in diameter, go to each stoker windbox.

This plant is situated midway between Youngstown, Ohio, and New Castle, Pa., on the Mahoning River at the state line and serves in addition to these cities, Sharon, Farrell and many smaller towns and villages. The output is taken by industrial plants, local and interurban street railways connecting these cities and by domestic consumers. The load factor is unusually high, averaging between 65 and 70 per cent. The generating equipment consists of two 7500-kw. and three 15,000-kw. General Electric turbo alternators. Current is generated at 2300 v. and stepped up and distributed at 22,000 and 66,000 v.

RIVER WATER IS POLLUTED WITH SEWAGE

Probably the greatest factor in the situation necessitating greater steam generating capacity was the condition of the river water when it reached the plant after passing through the industrial section between Lowellville and Youngstown. The water is polluted with sewage, fine iron ore dust from blast furnaces, acid from pickling plants and the temperature is extremely high. The suspended matter causes dirty condensers and this in combination with the high river temperature (maximum noted at 120 deg. F.) raised the station water rate unusually high. Condensers are cleaned twice a week and sandblasted at intervals. These cooling water conditions exist the year round, the only difference being that the temperature falls to between 50 and 60 deg. F. in the winter season during the day when the heaviest demand is met and 40 to 50 deg. F. at night.

In the spring of 1923, work was started in the boiler room to modernize it. A new type of stoker tuyere, extension grate and dump plate was installed on the type AA4 stokers and the old hand dump mechanism was changed

to power dump. Two old engine drive 60,000-cu. ft. fans were removed and replaced by new turbine driven fans of the same capacity. Starting in the late summer, a system of centralized combustion control, made by the Smoot Engineering Corp., was installed and a centralized control house was built in the center of the boiler room. This control consists of two master controllers, six forced draft fan regulators, 14 stoker engine speed regulators and 28 regulators controlling the volume of air to the boilers.

Gages, recording and indicating, were installed in the control house and in March, 1924, the installation was complete. During the installation, a boiler room log sheet was devised, systematic records were introduced and many operating and engineering changes made to increase efficiency and insure continuity of operating steam pressure and service.

Both the boiler control house and the control instruments are in charge of a shift operator whose duty is to observe and record readings for the log sheet and to take care of anything unusual in load conditions by manipulating the master controllers and communicating with the switchboard or pump-room to have changes made in the operation of auxiliaries. On the panel in front of the operator, is a multiple water manometer showing the air pressure in each individual stoker windbox and the pressure in the main air duct at its two extremities; six pressure gages showing the steam pressure in the nozzle chest of each of the six forced draft fan turbines; feed water pressure gage; steam pressure gage; service compressed air gage, water pressure on the overfire draft regulating system and a gage showing the pressure of the oil used as power in the combustion control system.

On either side of the panel is a pyrometer galvanometer which can be set on any one of the boilers by means of a 30-point switch in the center. At the operator's right, is a telautograph with which he can communicate in writing with the pump room or the engine room. A telephone is also provided. At his back are recording feed water, forced draft air pressure and steam pressure recording gages and a 12-in. clock.

On the rear inside wall of the control house are mounted seven Duplex Mono CO_2 recorders with the piping arranged so that one machine is used on four boilers, each boiler being on record once in two hours. The flue gas is conveyed a maximum distance of 250 ft. from the boilers to the control house through ¼-in. pipe, a system of aspirators being used. The vacuum line is equipped with a breaker to prevent damage to the machine in case of stoppage of the gas line. An Orsat is mounted on the column in the center of the control house and gas bags, equipped with tubing and aspirating bulbs, are placed convenient to the Orsat for taking hand samples of flue gas at any time. Each of the boilers is equipped with a hand flue gas sampling line that enters the boiler setting adjacent to the line leading to the automatic CO_2 recorder.

Clear View of Operating Floor From Control House

From the control house, the operator has a clear view of the entire boiler room and at all times he has his finger on the pulse of the whole steam generating plant. In case of trouble, it can be located and in most cases corrected without the operator even leaving the house. It has been found to be the nerve center of boiler room operation.

Methods of operation have been found to be dependent on the type of boiler control and its characteristics. The log sheet, Fig. 2a and Fig. 2b, for recording of operation data was of necessity built around the control installed and as there was no precedent, it had to be original. Readings are taken of the rate of steaming (boiler horsepower), windbox pressure and exit gas temperature of each boiler in service and recorded hourly. A mental average is taken from the charts of the CO_2 recorders every half hour, the reading recorded and the recorders shifted to other boilers. Readings of the draft over the fire on each boiler are taken from Ellison draft gages once in each shift and recorded; this being found to be frequent enough to check the operation of balanced draft regulators.

On the left hand side are columns which are characteristic of the control and show the static air pressure on the pneumatic dispatch lines from the master controllers to the various regulators and the rating meter. Two master controllers are provided, one taking care of 18 boilers and the other 10 boilers. The column of ratios shows the ratio of pressure actuating the stoker and volume air regulators, which indicate the ratio of pressure actuating the volume air regulators and forced draft fan regu-

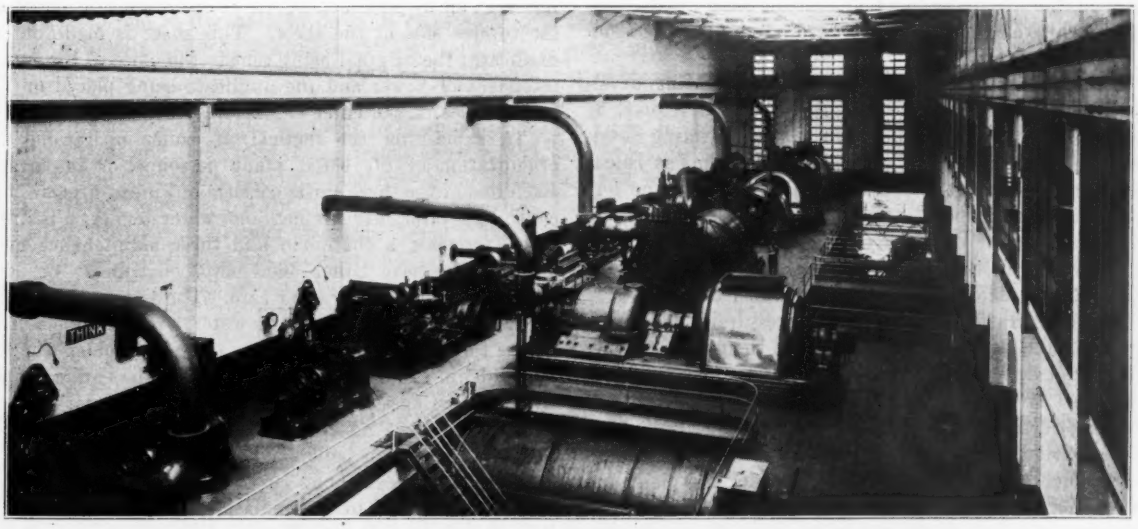


FIG. 1. ADDITIONS HAVE BEEN MADE TO THE PLANT AS THE LOAD INCREASED

TIME	1 BOILER H.P.	1 BOILER WINDBOX	1 BOILER CO_2	1 BOILER TEMP.	1 BOILER DRAFT	MS AIR FAN	2 MASTER RATING	2 MASTER COAL	2 MASTER AIR	2 MASTER FAN	RATIOS COAL AIR	RATIOS AIR FAN	FAN THROTTLE PRESSURES 1	2	3	4	5	6	STACK DRAFTS 1	2	3	4	5	DUCT PRESSURES EAST	CENTER	WEST	FEEDWATER PRESSURE	STEAM PRESSURE	OIL PRESSURE	AIR PRESSURE	FEEDWATER TEMPERATURE 1	2	3
1 A.M.																																	
2																																	
3																																	
4																																	
5																																	
6																																	
7																																	
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1 P.M.																																	
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6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	
AVERAGE																																	

	CONTROL OPER.	HEAD FIREMAN	MAINT. FORE.
6:30—1:30			
1:30—9:30			
9:30—6:30			

COAL ANALYSIS	%
MOISTURE	
VOLATILE	
FIXED CARBON	
ASH	
SULFUR	
B T U / # AS REC'D	

DAILY

TOTAL WATER EVAPORATED = POUNDS

TOTAL COAL FIRED = POUNDS

B T U PER POUND STEAM = B.T.U.

OVERALL BOILER EFFICIENCY = %

FIG. 2. ONE LARGE LOG SHEET WAS DEVELOPED TO MEET EQUIPMENT AND OPERATING CONDITIONS. SEE FIG. 2B FOR OTHER FORMS ON THIS LOG SHEET

lators which indicate the static air pressure being carried in the main air duct.

Fan throttle pressures are read every hour on the fans in service. When a fan is not in operation, the pressure gage reads zero and the space is left blank; this method affording a convenient means of checking fan operation in relation to the load being carried. Drafts at the base of each of the five stacks are taken with Ellison inclined draft gages once on each shift and recorded on the log. Main air duct pressures are read every hour, the pressures at the two ends of the duct being taken from the multiple windbox pressure gages and the pressure at the center of the duct, from a recording air pressure gage.

Feed water, steam, oil and water pressures are read every hour and recorded. Space is allotted on the log sheet to take hourly readings of the feed water temperature at each of the three heaters but at the present time, this is not done, the average water temperature being taken from recording thermometers and recorded on the turbine room log sheet.

Columns also show the average per cent rating developed by all boilers in service; average rating developed by the 10 boilers on the east end and the average rating developed by the 18 boilers on the west end. This is calculated every hour by the operator and entered in the log. The next column labeled "B. H. P.—CO_2" is the average CO_2 of each end of the house determined by comparing the average rating of these boilers with the air loading of the volume air regulators and will be explained later.

Balanced draft regulating water pressure is read from a gage on the panel and the indicated thousands of kilowatt station load read from an illuminated load indicator located at the end of boiler room, both of these readings being recorded hourly.

Revolution counters on all stokers furnish a convenient means of checking the coal consumption of the plant and also to check the operation of the stoker engine regulators. Readings are taken at the end of the day, the revolutions of all boilers on the same master controller should closely agree if the boiler has operated continuously. It might be mentioned here that it has been found impossible at this plant to derive a true constant for pounds of coal per stoker revolution. The quantity is greatly affected by the moisture in the coal and the degree of fineness of the coal, for it has been found to vary from 107 to 112 lb. of coal per revolution. It does, however, make a convenient instrument for checking the control and approximating rates of coal consumption.

At the bottom of the sheet can be seen data listed that is self-explanatory. All of this data is compiled and recorded on the log sheet by the efficiency department with the exception of the total stoker revolutions, total cars of ash and refuse and the average daily per cent CO_2 with its corresponding per cent excess air. The names of the control operator, head fireman and maintenance foreman of each shift are recorded in the lower left-hand corner. Remarks on unusual conditions of operation are placed on the reverse side of the sheet. This sheet is made out in duplicate; the original being sent to the office of the superintendent of power and the duplicate being placed on file in the office of the chief engineer.

In explaining the method of boiler operation, the organization of the boiler plant personnel is important. Each one of the three shifts consists of a head fireman, one control operator, five firemen, one water tender, a maintenance foreman, a chainman and three maintenance men. The firemen have either 3600 b.hp. (6 boilers) or 3000 b.hp. (5 boilers) under their care. The latter take care of their own water level and the water level in boilers fired by the former is taken care of by one watertender who has 10,600 b.hp. (18 boilers) to watch. All boilers are equipped with either Copes or Stets feed-water regulators.

Firemen have no control over the quantity of air or coal being fed to the boilers. Their sole responsibility is to keep the fires clean, holes covered and preserve the right contour of fuel bed by manipulation of the extension grate, the extension grate air damper and adjustment of the stroke distributing rams. In case of a sudden radical

EFFICIENCY DATA

Load 1000 KW	Average % Rating East	Average % Rating West	B.H.P. %Col. East	B.H.P. %Col. West	Bal. Draft Water Press.

STOKER REVOLUTIONS

R = 4
L = 3

	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
6.30—1.30																												
1.30—9.30																												
9.30—6.30																												
TOT. REVOL.																												
TOT. STROKES																												

	15		16		17		18		19		20		21		22		23		24		25		26		27		28	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
6.30—1.30																												
1.30—9.30																												
9.30—6.30																												
TOT. REVOL.																												
TOT. STROKES																												

TOTAL STOKER REVOLUTIONS =

TOTAL COAL = POUNDS COAL FED

TOTAL WATER FED TO BOILERS = POUNDS POUNDS COAL PUT IN BUNKERS

BLOW DOWN = POUNDS DIFFERENCE

TOTAL WATER EVAPORATED = POUNDS

EVAPORATION = POUNDS

AVERAGE STEAM TEMPERATURES = °

AVERAGE FEEDWATER TEMP. = °

BOILERS OFF LINE

BOILERS HOURS OPERATED = BOILER HOURS BANKED =

MONTH TO DATE		
TOTAL WATER EVAPORATED =	POUNDS	
TOTAL COAL FIRED =	POUNDS	
B.T.U. PER POUND COAL =	B.T.U.	
B.T.U. PER POUND STEAM =	B.T.U.	
OVERALL BOILER EFFICIENCY =	%	

TOTAL CARS ASH AND REFUSE =

POUND ASH AND REFUSE @ 1900 #/CAR = POUNDS

PERCENT ASH AND REFUSE OF COAL FIRED = %

PERCENT HEAT LOST IN ASHPIT = %

PERCENT COMMERCIAL COAL = % PERCENT STOCK COAL = %

BOILER ROOM AVERAGE CO_2 IN FLUE GASES = % EXCESS AIR = %

FIG. 2B. THIS IS PART OF THE LOG SHEET, A PORTION OF WHICH IS SHOWN IN FIG. 2A

change in coal quality or mechanical trouble with the stoker or regulator, causing an unusually light or heavy fire, he reports to the head fireman and the control operator; they investigate and if the condition warrants, artificial means are brought into play to get the fire back in shape again. The fireman is responsible for maintaining the CO_2 and for coke lost in the ashpit. He is required to record with chalk, on the stoker power boxes, the time of cleaning of his fires. This data is copied by the control operator and placed on file. A certain maximum interval between fire cleanings is allowed and varying with the average boiler rating no fire can operate longer than the interval set. No more than two of the fires are allowed to be cleaned simultaneously.

To facilitate following this rule, a fire cleaning indicator is hung about 10 ft. over the boiler control house where it is visible from all over boiler room. This indicator is divided into five horizontal compartments, with numerals from one to five painted on both glass sides of the compartments. Each compartment is separately lighted by an electric light, controlled by a switch located conveniently for operation by the firemen. Each fireman is assigned a number and when he starts to clean a fire he snaps the switch and lights the compartment showing his number. When he finishes cleaning that fire he turns his light out leaving another fireman free to clean one of his fires. In this way, each fireman and head fireman knows at a glance how many fires are being cleaned and who is doing the cleaning. The conditions of the fuel bed of each boiler is observed in the control house by observation of the pressures in the multiple windbox pressure gage.

Gages Placed for the Guidance of Firemen

As a guide to the fireman in the tending of his fires, he has a General Electric Co. steam flowmeter on each boiler indicating the boiler output in terms of boiler horsepower and a three in one gage indicating the draft in the last pass, the draft over the fire and the air pressure in the stoker windbox. An additional guide, a master rating meter illuminated and 24 in. in diameter is suspended in the center of the boiler room firing aisle about 20 ft. from the floor. This gage indicates the average output he should get from each boiler on the line. Two 24-in. double faced illuminated master steam pressure gages are suspended over the firing aisle, one at each end of the boiler room. A 20-in. double faced illuminated master feed-water pressure gage is located in a similar position in the center of the boiler room over the control house.

To explain this master rating meter it is necessary to revert back to the centralized combustion control. By means of a diaphragm, acted upon by the steam pressure and held balanced by a lever connected to an exhaust air cup in the main tunnel of the master controller, the air pressure in the tunnel is varied to suit the demand for steam. This static pressure is distributed to the various regulators simultaneously and serves to actuate them to increase or decrease the coal feed, the fan speed or the air supply. In the stoker regulation this actuation causes the engine to increase or decrease in speed until the oil pressure induced by centrifugal force in an oil pot, revolved by a drive from the engine, is sufficient to balance it. The actuation of the regulator causes the fan to decrease or increase in speed until the impact pressure of the air being delivered by the fan balances it. In the volume air control regulators the actuation causes the regulators to open or close a damper in the air ducts to the stoker until the velocity pressure, measured by a modification of a pitot tube, of the air passing through the ducts is sufficient to balance the actuation, both pressures acting upon a diaphragm and the two reacting against each other through a lever.

Air pressure of the master controller in the tunnel varies inversely with the steam pressure change so far a fall in steam pressure the main air-tunnel pressure rises sufficiently to increase the coal feed, air supply and fan speed to take care of the increase in steam demand that caused the decrease in steam pressure. As the actuation of the volume regulators is the same at all boilers, it follows that each boiler receives essentially the same quantity of air, for this actuation must be balanced by the velocity

pressure of the air going to the boiler and the velocity pressure is a direct measure of the volume of air flowing through the ducts.

With each boiler receiving the same quantity of coal and air, the air pressure in the actuating lines to the regulators is a direct indication of the quantity of combustion air supplied. This pressure is also an indication of the boiler horsepower output of each boiler receiving this quantity of air. In coal burning at a certain combustion efficiency, the coal and air supplied are both directly proportional to the boiler horsepower developed when the efficiency of heat absorption is constant. It follows, then, that the ratio of boiler output to air supply is a measure of the combustion efficiency, i.e. CO_2. This has been applied directly to operation and found to give a good indication of the condition of the fuel bed by indicating high or low CO_2 in the exit gases.

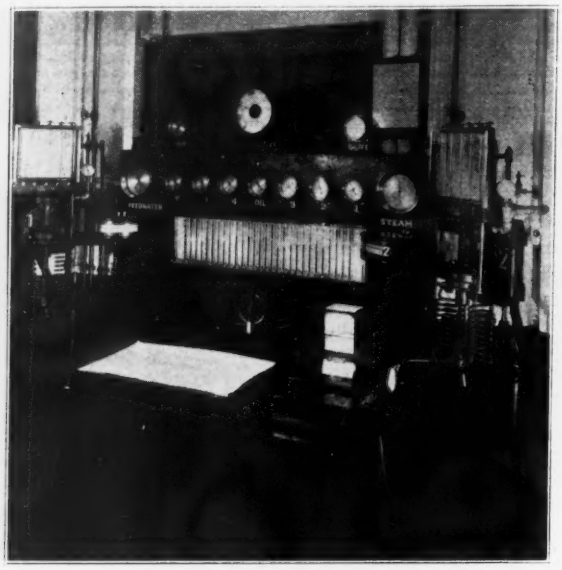


FIG. 3. MAIN CONTROL EQUIPMENT IS LOCATED IN THE CONTROL HOUSE

Static air pressure in the actuating line to the volume regulators is connected to the impact side of a standard Republic flowmeter body, the trailing pressure side of the meter body being open to the atmosphere. This pressure acts on the mercury level of the flowmeter and cuts resistance in or out depending on the air pressure actuation. This resistance acts in the electrical circuit of the flowmeter and swings the indicating hand of the galvanometer in the rating meter to a position on the dial that corresponds to the boiler output for a given per cent CO_2. This CO_2 is set at 12.5 per cent and if the boiler flowmeter indicates a smaller or larger output than the master rating meter calls for, the per cent CO_2 in exit gas is either smaller or larger proportionately; or to express it differently, the fire is using more or less than the standard number of cubic feet of air per boiler horsepower.

In addition to the master rating meter, a smaller meter is placed in the control house and the chief engineer's office for their guidance. By a special means of comparison of the average actual boiler horsepower being developed and the static pressure in the actuating line to the volume air regulators the efficiency of utilization of the air supplied is arrived at. The ratio of the average actual boiler horsepower being developed to the horsepower that would be developed if all boilers were giving 12.5 per cent CO_2 at that air supply gives the average actual CO_2 being formed. This has been found to be remarkably close to the average CO_2 of the boiler house as found by the CO_2 recorders. The average for a five months' operation, of the b.hp.-CO_2 (as it is called) was 11.76 per cent CO_2 for the whole plant and that by the CO_2 recorders over the same period was 12.02 per cent.

One feature of this centralized method of operation is the adaptation of the mathematical accuracy of theory to practice. If the CO_2 is a certain figure, which is lower than average on account of a change in the coal quality, to raise the per cent CO_2 up to the desired figure requires a definite mathematical decrease in the air supply or increase in coal supply. The control operator guided by curves and tabulated data on file can, by manipulation of the control, change either quantity the right amount required on all boilers. If at any time a definite per cent change is wanted on any one regulator, by referring to other curves he can do the same thing. By recording any such changes necessary, the performance of any boiler is watched and if trouble continues, the stoker and furnace are inspected for mechanical defects and if necessary, the fire is burned out and repairs made.

By means of the multiple windbox pressure gage, unusual firebed conditions are quickly seen and corrected. With all of the boilers receiving the same amounts of coal and air, they should be of uniform fuel bed resistance. Glancing along the multiple gage (a 28-tube water manometer using coffee as the liquid medium) a mental average is made of the windbox pressures. If one boiler shows less than the average pressure, it indicates that the fuel bed has less than the average resistance either because of a hole in the bed or the coal is hanging in the hoppers and not feeding, causing a light fuel bed. If the pressure in any one boiler is higher than the average, it indicates a higher fuel bed resistance than the average, caused by a dirty fire, or a heavy fire caused by the air being accidentally shut off at some time previous or a radical change in the coal quality in the one boiler and not in the others. In either case the condition is noticed and upon inspection of the fire and the stoker the cause is found and steps taken to bring about normal conditions.

Another method of checking operation is being tried. By comparison of flue gas temperatures and boiler horsepower output of each boiler, the combustion efficiency can be checked independently of the CO_2 recorders. Tests were run to determine the stack temperatures at various boiler ratings and operating at various per cent CO_2 in the flue gas. It is a well-known fact that at a constant rate of coal supply the stack temperature varies with the CO_2 but in the opposite direction up to a certain limit when with excessive air supply, the temperature falls due to cooling. As the CO_2 goes up the stack temperature goes down. The boilers were divided into groups that have the same kind of equipment and test curves were drawn for each group showing the stack temperature plotted against the boiler output at different per cent CO_2 in the flue gases. After taking readings of the stack temperature and rating of each boiler, the curves are consulted. If the temperature as found, is higher than that called for by the curve, the length of time in service of the boiler is considered with

reference to the cleanliness of the heating surface and, if thought high, means are taken to reduce it by increasing the CO_2. This method is found to be correct but so many factors enter into the final result that there is some doubt of its adaptability to practice. For a small number of boilers it would be more applicable than on many, as the time involved in referring to the curves for each boiler is excessive where there are many boilers.

Records Are Posted on a Blackboard

It has been found that to get the best results from the fireroom force, due publicity with its resultant credit or censure in regard to the operating results brings forth the best efforts. At this plant a large blackboard is erected on the wall in the center of the boiler room. On it are posted each shift's daily average percent CO_2, the number of cases of lost coke and the boilers that are dumping the coke. The ash is dumped into narrow gage cars in the boiler room basement and pulled to an ash hoist by a storage battery locomotive. As the ashpit doors are opened manually, the ash man is of necessity, an observer of what is discharged from the pit and he is instructed to take a written note of the number of the boiler that discharges any appreciable amount of coke.

This is reported at the end of each day and the proper fireman charged with the lost coke. There is room for error in arriving at the true results from this method of posting results of combustion efficiency but absolute accuracy is relatively unimportant. The benefit derived is a psychological one rather than scientific, as each member of the operating force knows that his performance is under constant observation and he acts accordingly. The posting of results creates a friendly spirit of rivalry between the shifts.

On this blackboard are also posted the daily average CO_2 of all shifts and the number of cases of boilers having a higher average CO_2 for their half hour period than 15.5 per cent. The firemen then have a range of 12.0 to 15.5 per cent CO_2 in which to work. This limiting of maximum CO_2 became necessary on account of some fires at times operating at 17 to 18 per cent CO_2 with no CO, resulting in high furnace temperature and causing high furnace maintenance costs. At the end of the month the monthly average per cent CO_2 for each shift and the name of each fireman and the number of cases of lost coke reported against him are posted.

Each boiler is equipped with either a Vulcan or a Diamond soot blower, seven or eight elements being provided to each boiler. The flues are blown three times a day on all the boilers in service. The difficulty and expense in maintaining a soot blower element in the first pass of the boilers under the front header was a serious problem. The problem was solved by using ordinary extra heavy wrought iron pipe instead of calorized pipe and ventilating the element by means of a ¾-in. pipe connected to the stoker windbox which admits air to the element as long as there is a pressure in the windbox. When the flue is blown a check valve prevents a flow of steam back into the windbox. No detectable reduction was found in the present CO_2 of the flue gas by this admission of cooling air. These front-pass soot blower elements have been found to decrease materially the total quantity of slag deposits on the tubes which results in considerable reduction in the draft loss through that pass.

Pressure Must Not Develop in the Furnace

One of the outstanding operating difficulties encountered, was that at boiler ratings above 150 per cent on some boilers, a pressure was developed in the furnace, sparks flew out the observation doors and the doors became red-hot. Upon investigation it was found that this was the result of low CO_2 and unusually high draft loss through parts of the setting and the superheaters. The efficiency of combustion was raised but still the high boiler draft loss prevented higher than usual ratings. Dimensions of all the gas passage areas were taken and modifications in the backs of bridge walls and baffles were made and conditions were improved somewhat. Nine of the boilers were found to be the worst offenders, these nine having been originally designed for saturated steam but later equipped with superheaters. The space between the tops of the tubes and the steam drums was too restricted, so it was

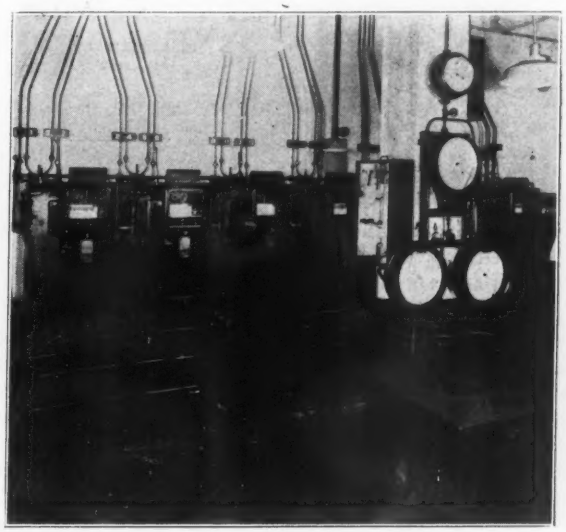


FIG. 4. RECORDING PRESSURE GAGES AND CO_2 RECORDERS ARE ALSO LOCATED IN THE CONTROL HOUSE

decided to sacrifice efficiency of the boilers by cutting out some of the superheater elements in order to gain in coal burning capacity without the ruinous condition of pressure in the furnace.

This was done and an average of 35 per cent of each superheater element was removed. The result was a decrease in draft drop, a 16 per cent decrease in superheat at 215 per cent of rating and an increase in boiler capacity of 11 per cent with the same draft in the last pass and the same CO_2 (13 per cent), in the flue gas. The improvement in draft conditions as noted is partly due to cleaning the external surface of the superheaters by sandblasting; this method of cleaning being found exceedingly effective in removing the scale and baked flue dust.

Ventilated side and front walls were installed in 18 boilers and good results were obtained. Two sidewall cleaners were kept busy before installation; after installation only one was found necessary to take care of the other 10 boilers. With ventilated walls it has been found that it is necessary to clean the sidewalls only once a week even with a poor grade of coal and then it is a 10-min. job instead of 30 min. and the fireman can take care of it himself. Experiments are now being conducted on several

FIG. 5. FIRE-CLEANING INDICATOR, MASTER RATING METER AND THE MASTER FEED WATER PRESSURE INDICATORS ARE LOCATED ABOVE THE FIRING AISLE

types of ventilated walls, air backs and side tuyeres and upon the conclusion of the tests all boilers will be equipped with the approved design. The firemen can then clean their own sidewalls, doing away with the necessity of a sidewall man. The clinker on ventilated walls is mostly honeycombed and breaks off readily without bringing part of the wall with it.

Owing to high power demands over the last year and a half, boilers could not be left out of service long enough to give the stokers and furnace walls the maintenance attention needed. The natural result was that the stroke of the distributing rams and the extension grates became unequal and caused uneven fuel beds and high stoker replacement costs. The moving parts of each stoker were dismantled and the length of the strokes standardized and lost motion of levers was removed by bushing or plugging and redrilling holes. Fuel control plates were installed in ramboxes under the rambox cap, which deflected the incoming coal up and helped to maintain the proper fuel bed contour. While burning coal of poor quality, difficulty was had in removing clinker that reached back into the rambox. In order to overcome this, a distributing ram extension, 24 in. long, was designed and installed in one stoker and has shown effective results.

Stoker power boxes are overhauled every 6 mo. and it is planned to overhaul completely each stoker once a year. The increase in combustion efficiency and decrease in mechanical troubles through stoker overhauling far exceeded expectations.

Owing to the treatment necessary to make the river water usable for the boilers, a considerable quantity of soluble salts is carried to the boilers in the make-up water. In an effort to discover if all the boiler blowdown was necessary to avoid priming or foaming, a series of tests were made on one boiler allowing the salt concentration to increase at will. There was found to be no priming even when the salt concentration reached 60 gr. per gal. Working on this basis, a new blowdown schedule was arranged and a material reduction made in the amount of water blown to the sewer. During the last 3 mo., while experiments were going on, a 30 per cent reduction was made in the water blowdown. To date no unfavorable results have been found and it is expected that when the river pollution decreases in the winter months, no blowdown will be necessary at all. Each boiler is off the line for repairs and washing every three weeks at which time the boiler is drained and filled with fresh water. Each boiler is turbined once a year and not more than $\frac{1}{32}$ in. of scale has been found in any tube.

All coal is weighed on standard gage track scales, crushed, if necessary, elevated to bunkers by belts and discharged into the bunkers by trippers. As the coal goes up the belt, a sample is taken at intervals and at the end of the day the gross sample is quartered and crushed for analysis. A separate sample is taken for moisture. The bunkers are completely filled at 4 p.m. and the coal put up one day gets down to the hoppers through swinging chutes between 8 a.m. and noon of the next day. At noon of the day the coal is being burned, the coal analysis is on file in the control house for the guidance of the head fireman and control operator. In this way changes in coal-air ratios, to maintain uniform fuel bed resistance, can be anticipated.

Water fed to boilers is all measured by Venturi meters. The water blown down and the water required to fill the boilers is reported and constants are used to determine the total water which must be deducted from the water fed to boilers in order to find the water evaporated. All ash and refuse is weighed on track scales and this total used to compute the monthly ash-pit loss. Water is returned to the boilers from main unit drips through two Holly loop systems but owing to having no means of measuring this quantity, no credit can be given the boilers for evaporating it.

With the application of modern scientific methods of boiler operation, comes the question of just how far to

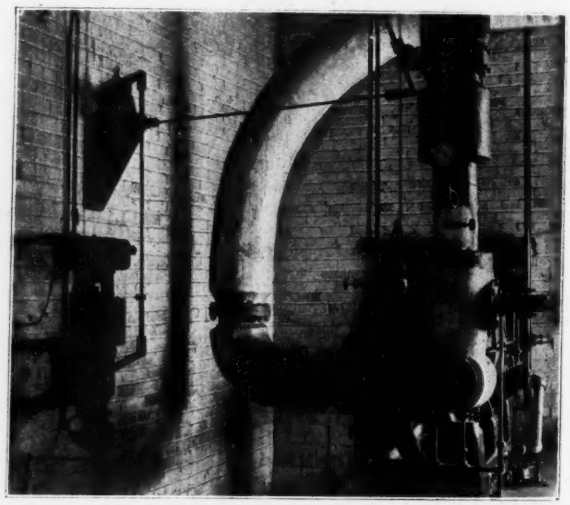


FIG. 6. STEAM END AND CONTROL DEVICES ON A FORCED DRAFT FAN

go in the applying of theory to operating practice. If all boiler room operatives were technical men, the answer would be obvious but when this is not the case, the problem becomes more complicated. The solution works itself into a cut and try and try again proposition that will prove or disprove any application of theory to practice.

With centralized combustion control only a few need to be technical or semi-technical men, provided these men have the authority to carry out their ideas with or without the approval of non-technical men. It is true that the better understanding a man has of principles involved in his work, the better will be the performance of that work but this is "The consummation devoutly to be wished" and not conditions as they are found. It follows then that, for the best operation, the technical end must be taken care of by an experienced technical man and the work of the others must be confined to things done mechanically. If a fireman has nothing to do but keep his fires in shape and does not have to regulate the coal or air supply, he will be able to do the former far better than he would be able to do both. The average fireman is not prone to reason his way through difficulties and would prefer to be given definite and brief instructions to follow for each phase of operation. If the situation cannot be met by any instructions he has received, he can then report to his superior who will take charge of the situation and thus leave the fireman free to follow his routine.

Listed in the table given herewith are some of the most important operating averages covering 1923 and 1924. The per cent CO_2 as given is the actual operating average and includes fire cleaning intervals and all situations of operation while the boilers were steaming. The boiler efficiency is the overall figure, no deductions being made for auxiliary power. Particular attention is called to the ash and sulphur content of the coal and the heat value. The average condenser cooling water temperature is given to show the seasonal change in steam demand for the same power output.

The average rating of all boilers in service is approximately 145 per cent. The minimum average rating permitted before banking boilers is 100 to 110 per cent of rating. The maximum average rating developed by the 10 boilers installed latest is 225 per cent and for the other 18 older boilers, is 180 to 190 per cent at maximum power output. The former are operated continuously at 25 to 35 per cent higher than the latter on account of better draft conditions. An idea of the demands on the station can be seen when during the month of April, this year, there was a momentary output of 59,000 kw. and a total output for the hour of 57,000 kw.-hr.

Steam Pressure Is Maintained Practically Constant

One of the biggest advantages resulting from the changes made in the boiler plant is the ability to maintain continuously the correct operating steam pressure. Previous to the time these changes were made, the actual range of steam pressure was about 40 lb. and too much of the time the pressure was at the bottom of the limit. At the present time, it is an exceptional cause that will change the steam pressure more than 5 lb. and even these exceptions will not cause a change of more than 15 lb. While carrying a load of 48,000 kw., as much as 45 per cent has been dropped without any previous notice and either several boilers would have their safety valves simmering a few minutes or one boiler would pop for a minute. An increase in load of 50 per cent has been picked up without dropping the steam pressure more than 4 lb. A load of 20,000 kw. has been picked up, dropped and shifted back and forth for 20 min. in multiples of 5000 kw. without a boiler popping or the pressure changing more than 6 lb.

In the rehabilitation of an old plant considerable missionary work must be done with the operating force. The transition from old to new methods and ideas is necessarily slow and calls for considerable perseverance and nerve on the part of those making the changes. Diplomacy is as necessary as engineering ability, for though direct orders can be given for all phases of operation, the net results of the changes made will not be as great as they would be, if the operating force were in sympathy with the ideas. It is for this reason that greater benefits are expected in the future from the work that has been done than have been realized to date. The performance is gradually getting better; each month shows an improvement.

AVERAGE RESULTS OBTAINED DURING 1923 AND 1924

1923	BOILER EFF.	B.T.U. PER # COAL AS FIRED.	% ASH IN DRY COAL	% SULPHUR IN DRY COAL	AVG. RIVER WATER TEMPERATURE °F.	% CO_2 IN FLUE GAS
January	68.97 %	11,409	14.00 %	2.50 %	52°	
February	66.73	11,641	14.83	2.58	55	
March	67.30	11,730	15.22	2.60	49	
April	69.90	11,776	14.08	3.17	69	
May	69.60	11,743	14.02	2.91	81	
June	68.50	11,781	13.60	3.05	100	
July	69.50	11,603	14.50	3.12	103	
August	69.90	11,822	14.00	3.13	103	
September	72.20	11,532	14.15	3.11	100	
October	72.20	11,293	15.66	3.75	91	
November	69.20	11,428	16.17	3.03	80	
December	73.00	11,760	13.30	3.00	80	
AVERAGE	69.66 %	11,627	14.30 %	2.22 %	78°	
1924						
January	73.6%	11,035	15.47 %	2.87 %	45°	
February	69.8	11,151	15.89	3.49	54	
March	71.2	11,363	14.82	2.42	48	11.21 %
April	72.2	11,650	14.55	2.22	59	11.75
May	73.4	12,187	11.91	2.10	64	11.82
June	74.1	12,200	12.35	2.20	78	11.99
July	75.0	12,848	10.34	1.51	84	11.94
August	75.4	12,659	10.35	1.65	94	12.52
AVERAGE	73.1 %	11,887	13.22 %	2.51 %	66	11.87 %

This plant was originally built in 1912 with an initial capacity of 15,000 kw. Additions were made in 1916-1918 and 1922 and the plant is now complete, being as large as the resource of water supply will allow. The recent installation of auxiliary equipment and rehabilitation of old equipment took place under the direction of Stevens & Wood, Inc., of New York.

The writer wishes to acknowledge his appreciation of the valuable assistance given by A. Carnegie, superintendent of power, in the preparation of this paper and in securing the photographs.

Short belt drives consist of an idler pulley placed on the slack side of the belt close to the driving pulley. The idler pulley is carried on an arm swung from a frame and is free to raise and lower, simply floating on the belt. The idler pulley is of just sufficient weight to take up the slack and hold the belt against the driving pulley.

In operation, when the power to be transmitted increases, the tension on the tight side of the belt also increases, which lengthens the slack side of the belt; immediately the idler pulley lowers, takes up the slack and at the same time automatically wraps the belt further around the driving pulley, giving a greater arc of contact for the greater power being transmitted. With the short belt drive there is no initial tension on the belt. When the drive is stopped, the only strain on the belt is due to the weight of the idler pulley.

Purification of Feed Water Containing Oil

Oily Feed Water Can Be Traced to All Parts of the Steam-Using System. By C. E. Joos

WHILE the introduction of turbine units for prime movers and auxiliaries largely eliminates the contamination due to cylinder lubrication, in the average industrial plant the reciprocating units still survive. So long as this condition exists the presence of oil in the feed water is likely to be a problem of no small magnitude, considering that even a grain of oil per gallon in the supply will mean anywhere from 10 to 100 grains in the boiler water, according to the rate of evaporation.

Sources of Contamination

Oil may be present in the feed water due to one of two reasons or both.

1. Initially present in the raw supply due to effluents from industrial plants, etc.
2. Present in the condensed steam by reason of cylinder lubrication.

Surface streams are the refuse collectors of industrial plants disposing of worthless by-products and while prohibited by law in a few localities the practice is quite general. It is therefore, safe to assume that such contamination exists in many industrial feed waters.

Some of the constituents of this contamination have no detrimental effect on boiler feed water and it is, therefore, the purpose of this paper to deal exclusively with the effect of oil and grease. In most cases, however, oil gains entry to the boiler from exhaust steam, due to cylinder lubrication.

Kinds of Oil

For our purpose in considering the probable effect on the steaming unit, the oil may be divided into two divisions, namely, that of saponifiable and unsaponifiable oils.

By saponifiable material we mean those oils or greases that will unite with the treating sodas usually present within boilers where the elimination of scale is a consideration, to form soap. The unsaponifiable material is that class which does not react chemically with soda. In the former are found greases such as tallow, vegetable oils, etc., and compounded cylinder oils because of their content of fatty materials. Some classes of oxidized cylinder oils are easily saponified even though they are derived from a mineral oil which belongs in the second class. The second class consists of 100 per cent straight mineral oils.

At this time it may be well to define the two states which oil assumes in water, commonly termed free oil and emulsified oil. Free oil means that the particles are of such size to be easily separated from the water by the ordinary means of gravitation or by simple filtration through a porous paper as a filter or blotting paper. Emulsified oil, on the other hand, is so finely divided that the laws of gravitation do not play a part in the separation, but the fine particles generally will pass through the ordinary paper and cloth used commercially for filtering purposes. These particles can be seen under the microscope and while they vary in size some of the globules are only 0.000,01 in. in diameter, in view of which the failure of ordinary methods of filtration is apparent.

In the majority of cases the effects produced are:

1. Foaming and priming.
2. Overheating of boiler plates.
3. Corrosion.

Effect of Foaming and Priming

A line of demarcation between foaming and priming is drawn inasmuch as these effects are sometimes considered as one. Foaming is more or less a surface condition in which the steam space becomes either partially or totally filled with bubbles. Priming, on the other hand, is violent ebullition in which the steam contains intermittent slugs of water. The effect produced is that of many small explosions occuring within the boiler water.

Foaming is confined to saponifiable oil by reason of the latter's soap-forming properties in conjunction with caustic soda and soda ash always present in a treated water. The condition may be compared with that of placing a cake of soap within the steam drum, the effect of which should not greatly tax the imagination.

This condition, unfortunately cannot be corrected by blowing down as is the case with priming when oil is not a consideration. The steam is continually contaminated with excess moisture which is hard to eliminate even with the best types of steam separators as the foam or bubbles are believed to remain in a floating or suspended condition. Therefore, the condition is usually only revealed when the boiler is taken off the line and inspected. Soft oily deposits, heavier at the water line, are commonly found in the drums of a water-tube boiler. Because of the suspended matter present these deposits are quite bulky and when analyzed it is found that the oil exists in just sufficient quantity to act as a binder. The following analysis is a sample of deposit of the most recent case of contamination that has come to the writer's attention. (Incidentally, this boiler plant was troubled with some steam contamination and bulged plates, but these effects will be discussed later.)

Recent investigation of foaming in a horizontal return tubular boiler showed the condition traceable directly to oil, by the fact that the entire steam space of the boiler was covered with a thick deposit of a soapy nature. An analysis of this deposit was found to be as given in Table I.

TABLE I. ANALYSIS OF SCALE FROM STEAM SPACE OF BOILER

Oil	20.0%
Silica	4.0%
Iron Oxide	8.2%
Calcium Carbonate	62.8%
Magnesium Carbonate	4.4%
	99.4%

The fact that this condition existed seems to prove that in case of foaming the steam space becomes filled with froth or bubbles.

It is, of course, evident that the mere forming of bubbles within the steaming unit is not of itself a problem. The problem occurs when the bubbles or froth are carried

over with the steam, for quite naturally the suspended particles of sludge are carried over as well.

Just how fast these deposits will build up and pave the way for trouble and expense in power accessories is evident when we see from the above typical analysis that sludge forms by far the largest percentage of the deposit.

The effect of deposits in power accessories may be seen from the following illustration:

Perhaps, the most serious and expensive effect is that of turbine blade deposits, a comparatively common condition. In this connection, it must be remembered that the oil or soap, as the case may be, under ordinary boiler temperatures is reduced to a liquid, state and this flows quite readily with the steam.

Upon reaching the turbine the steam gradually gives up its heat in performing its mechanical work and thus the oil contained in the steam becomes thicker with the drop in temperature of the steam with the result that the contamination finally congeals and acts as a binder in cementing the suspended impurities. It need hardly be said that this situation results in a greatly increased water rate of the turbine unit.

Several years ago, the writer recalls seeing the rotor of a large turbo-generator partially filled with deposit. The nature of this deposit was such that it would not

TABLE II. TYPICAL ANALYSIS OF SCALE DEPOSITED BY STEAM

Oil	24.88%
Silica	13.80%
Iron and Alumina	6.19%
Calcium Sulphate	0.03%
Calcium Carbonate	55.10%

uniformly distribute over the surface, hence the excessive vibration at the normal speed of the machine tore away so many of the blades that the entire rotor had to be re-bladed. Any person familiar with turbine construction will promptly recognize the large unnecessary expense to the plant all on account of a few pounds of oily deposit.

If superheaters are in service it is only a question of time until their function will be interfered with as they become plugged up with the contamination.

When it is remembered that thousands of dollars are expended for pipe bends for the elimination of friction in steam lines, it will be seen that these oily contaminations which lodge in the lines decrease power efficiency by increasing friction and thus defeat the very purpose of a well-planned and constructed steam pipe installation.

Priming is usually more serious in its effects in that its violence and volume naturally causes greater contamination of steam as compared with foaming.

Priming, as it is influenced by the presence of oil is chiefly due to the finely divided state of the oil throughout the water. In a case coming to the writer's notice recently, it was seen that the oil was so finely divided as to give the boiler water the appearance of milk. In this instance, the boiler water contained 40 grains of oil per gallon and priming was so serious that the traps throughout the plant became inoperative, due to the large quantities of sludge carried over. This condition has since been corrected by discharging the oily condensate into the sewer instead of the open heater, with the result at the present time, that steam is generated with practically no moisture as compared with a previous moisture content of approximately 20 per cent.

If the reader wishes to gain some idea of the effect of oil in a boiler water, the following simple experiments will be useful:

Place some of the oily water, preferably in a glass receptacle over a small gas flame. It will be seen that apparently no evaporation is taking place when suddenly the vessel will almost empty itself with a violence severe enough actually to move the receptacle.

Another experiment carried out by one writer illustrates this effect even more vividly. A ball of copper or iron, suspended on a wire is brought to a white heat and then dipped into a receptacle of clean water free from oil. The ball will be quickly quenched, accompanied by much hissing and evolution of the steam. When the procedure is repeated with an oily water, there will be little hissing sound and the metal will be slow to quench. Furthermore, there will be little if any steam given off and the ball will be seen surrounded by a shell of vapor resembling soap bubbles. The metal cooling slowly, the shell of the vapor becomes thinner and finally collapses with a report, releasing a volume of steam. If the experiment is conducted with a glass receptacle, it is quite likely to be broken, so that the whole effect is that of a boiler explosion in miniature.

If the more moderate condition of foaming causes superheater, steam line and turbine blade deposits, the effect of priming will be quite evident.

Aside from the expensive shut downs and repairs that may take place under these conditions, the loss of hot water would be surprising if the amount of moisture carried over were known and this calculated in terms of dollars and cents.

Corrosion

Corrosion of boiler plates due to oil is limited to that class of oils and greases which break up under heat and pressure to form organic acids; obviously, this condition occurs with highly compounded or vegetable oils.

In the presence of treating sodas, however, the corrosive qualities are neutralized before pitting takes place, but in this connection it is well to remember that where waters are treated with compounds and no definite control over the soda concentration is exercised, the corrosion may proceed at times when an excess of soda is not present. In cases of waters high in permanent hardness much of the soda introduced is destroyed by the scale-forming salts as for instance, calcium sulphate. It is obvious, therefore, that when such corrosion takes place, in the presence of treating agents, there has not been sufficient excess of soda or alkalinity as it is called in chemical terms.

It has been the writer's experience that an alkalinity of 15 grains per gallon is sufficient to arrest corrosion due to acids either mineral or organic or that due to magnesium chloride which can be classed as mineral acid corrosion.

Corrosion due to the presence of oil in water, however, is not a common condition, and is not as serious as the other effects outlined herein.

This is perhaps the most serious effect of oil in boiler water. Even small quantities of oil by reason of their insulating effect cause a decided falling off of evaporation of the water into steam, as it is quite evident that the insulating effect retards the natural transmission of heat

causing an increase in the temperature of the metal which must ultimately result in the metal's failure.

This becomes more significant when it is realized that a film of grease 0.01 in. thick, a layer of scale 0.1 in. thick and boiler plate 10 in. thick each offer practically the same resistance to heat transmission. In many cases, however, in fact in practically all cases that have come under the writer's observation, oil may be present without these disastrous effects. This is due, primarily to the fact that the particles of sludge (calcium carbonate) act as a coagulent or absorbent which prevents the film of oil adhering directly to the boiler metal. In this connection the presence of alkaline sodas such as caustic soda and soda ash together with the sludge have the effect of preventing films of grease adhering to the tubes. Where oil is fed into boilers treated with sodas the oil is usually found in soft deposits near the water line in the steam drums. In one plant where oil was a source of trouble, over 40 grains of oil were found in the boiler water, nevertheless no tube failures had resulted. This was no doubt, due to a portion of the feed water being treated through a softener united with the remaining raw water, resulting in sludge precipitation, together with an alkaline condition of the boiler water.

Overheated plates are an especially serious problem when surface condensers are in service and the boiler make-up water is composed largely of distilled water. In this case, the oil being finely divided throughout the entire volume of water, results in a fairly uniform coating over the tube surface. This coating, containing just a little sludge contamination, is much more resistant to heat transmission, with the inevitable failure of the metal.

Instances of this kind are more common with marine boiler installations than with the usual stationary power plant.

Several years ago, the writer remembers an instance of an oil burning ship calling for assistance, being unable to proceed under its own steam. On investigation, it was found that the oil heater had been plugged and when pressure was applied in an effort to free the obstructions, some of the tubes failed, thus causing oil to be carried with the condensed steam. The oil thus carried into the boilers caused so many tube losses that the ship was made inoperative. This, of course, is an exceptional case; nevertheless it illustrates the point.

Methods of Detection and Estimation

Thus far, we have dealt with the evils brought about by the presence of oil or grease. Our discussion would be of little value if it did not offer any corrective measures.

Fortunately, minute quantities of oil are easily detected by the naked eye, the emulsified condition of the oil causing the water to appear cloudy when it would otherwise be clear. A simple way to determine the presence of oil in water is to suspend in it a thin strip of camphor. If the strip moves sluggishly, it is a certain sign of the presence of oil; if on the other hand, it darts about rapidly, no oil is present. In the majority of cases of oil contamination, however, it may be detected by the naked eye.

Quantitive estimation is easily carried out by dissolving the oil in a solvent and then evaporating the solvent, the result leaving the oil in a solvent which we wish to obtain. If a 500 c.c. contaminated sample is mixed and shaken with 100 c.c. of distilled ether and allowed to stand for a short period, the two liquids will separate. The ether is then drawn off, distilled to a small volume and then washed with fresh ether and the resultant mixture is added to a small weighed dish and placed in a drying oven, to evaporate the ether.

There are, of course, many other methods, which, being common to good chemical text books, are omitted here.

Methods of Elimination

In considering the methods of elimination of oil contamination, the state in which the oil is present is the paramount consideration. Generally speaking, two methods are employed, one being mechanical and the other chemical or a combination of both.

Oil that is present in the free state can be eliminated by mechanical means alone and when present as such in steam, a good oil separator serves the purpose. In this connection, the velocity of the steam going through the separator must be low enough to prevent the atomization of the oil particles and thereby prevent their entrainment in with the main body of the steam.

Inasmuch as most separators both for separation of moisture from steam and oil from steam are sold on this basis, little trouble is encountered from this cause. The above, of course, refers to the baffle type of separator. The reverse prevails with the centrifugal type in which high velocities are necessary for the maintenance of efficient separation.

If oil is to be separated from water, in which the oil is in a free state, the usual methods of filtering through porous paper or finely woven cloth prove effective. Turkish toweling is used with certain types of filters with good success.

Where the oil, as in the case of a contaminated stream is present in large quantities, the separation can be effected by simply baffling the reservoir, well or tank into which the oil contaminated water flows. By this means, the oil is made to overflow while the clear water can be drawn from the lower part of the reservoir. It is quite obvious that efficient separation can only take place under this method when the water flows slowly, that is flowing with a low velocity through the system.

Separation of free oil from water presents no difficult problem; oil in the emulsified state, however, requires more elaborate means. As stated before, the globules are so fine that they readily pass through the ordinary filtering mediums with ease. The first step, therefore, is that of coagulating these minute particles into larger particles so that mechanical filtration is possible. This may be brought about in a number of ways:

1. Coagulation by means of chemicals such as alum, ferrous sulphate and caustic soda
2. By an electric current
3. By chilling the water

Perhaps the first method is the most simple and economical and the only one on which the ordinary rules of coagulation need by followed.

Coagulation of this nature is different from softening of water in that the coagulating chemicals need not be proportioned to the amount of oil contained in the water, thus materially simplifying the process.

In this method just enough of the chemicals need be fed to form a flock sufficient to entangle the oil particles and carry them down. Practice has shown that between 1

and 2 grains per gallon, (1.4-2.9 lb. per 10,000 gal.) of alum is sufficient for all practical purposes.

If a raw water is to be so treated, alum alone can be used if the content of carbonates is sufficient to precipitate the alum. In the case of condensed steam, however, it is quite obvious that an alkaline agent like soda ash or caustic soda must be used to effect this precipitation.

Practically, any precipitate can be used for this purpose and where a softening system is in use, the coagulation may be done within such equipment.

In many cases where oil in a small amount of condensate causes trouble and a softener is in use, it becomes evident that the problem can be most easily solved by mixing the condensate with the supply to be softened.

In this case the calcium and magnesium precipitate become effective in much the same manner as an alum or iron flock.

Whenever the oil is coagulated the resultant sludge must be removed either by filtration or settling, depending entirely, of course, on the conditions under which the coagulation takes place. In cases where large storage space is not available, filtering is the only means that can be used.

Coagulation by the electric current method is practically the same as that by a chemical precipitate. In this process, two iron electrodes are used and by the wasting away of the positive electrode, ferric hydrate is ultimately formed which in point of coagulation is no different from that of alum coagulation. Inasmuch as this method is quite expensive, it finds little use under modern practice.

TABLE III. ANALYSIS OF CONDENSER DEPOSIT

Water	63.50%
Oil	9.90%
Silica	0.47%
Iron and alumina	0.17%
Calcium sulphate	0.37%
Calcium carbonate	25.59%

Chilling the water is not a practical method for the power plant, but does find use in ice plants, manufacturing distilled water ice. In such ice plants, oil contamination can be eliminated by simple mechanical filtration if the water is chilled. In this method, an ordinary filter will remove oil when it is placed after the fore-cooler, but fails to function if the water is warm, the reason being that the low temperature effects coagulation and the larger particles so formed are easily filtered out.

In many cases, it is not necessary to dose the water with coagulating chemicals, but simply to pass the oil contaminated water over a precipitate of aluminum hydrate, ferric hydrate or silic acid, which is held on a cloth or coarse filtering medium.

In this connection the writer has achieved good results by simply placing several layers of cheese cloth on top of a charcoal filter, and on this placing loosely a precipitate of Aluminum Hydrate. This filtering medium furnished oil free water for 3 months before it needed further renewal.

Care must be exercised, however, in getting the material placed just right, for if it is present in too great a bulk, the drop in pressure through the medium will add a serious handicap to the flow.

Removal of Oily Turbine Blade Deposits

Deposits which adhere to turbine parts by reason of the binding qualities of oil are easily removed by using a solvent such as kerosene. By feeding kerosene with the steam, the solvent action removes the oil or binding properties and the sludge remaining is removed by the action of the steam itself.

When such a procedure is followed with surface condensers in use, the condensate during the cleaning period, of course, becomes contaminated and should be disposed to a sewer. If this is not done, the oil will return to the boilers and the detrimental action will continue in a cycle.

Oil removal by coagulation is quite common practice on sea-going vessels where oil contamination may become a vital factor in the operation of the vessel.

Summary

Generally speaking, the contamination of oil in feed water is a serious problem especially where the feed water is composed largely of condensate, provided, however, sludge accumulation or soda is not present, (the latter from the standpoint of boiler metal failures).

TABLE IV. DEPOSIT FROM DRY PIPE

Silica	9.18%
Iron and alumina	10.39%
Sodium sulphate	2.00%
Calcium carbonate	74.69%
Oil	3.75%

In point of operating efficiency, oil has a high insulating effect even though it be mixed with sludge and if for no other reason than this, should be eliminated.

Compound oils are more detrimental in their effects than straight mineral oils in that they saponify with the treating sodas when allowed to gain entrance to the boiler, causing, foaming or priming, or both and if insufficient soda be present, may cause serious corrosion.

Where oil cannot be eliminated, a mineral oil should be substituted for the compound variety wherever possible.

If contamination results from a condensate return which makes up only a small part of the boiler feed, it should be discarded. If, however, it makes up a comparatively large portion and a softening system is in service the oil can be eliminated by mixing it with the raw supply.

For some years Robert Maclaurin of Glasgow has been working on a method for low temperature carbonization of coal. The latest tests have been so satisfactory that the Glasgow Corporation Gas Committee has ordered a plant with capacity of 36,500 T. of coal a year. Gas produced will be burned under steam boilers, the oils, sulphate of ammonia and smokeless fuel being sold.

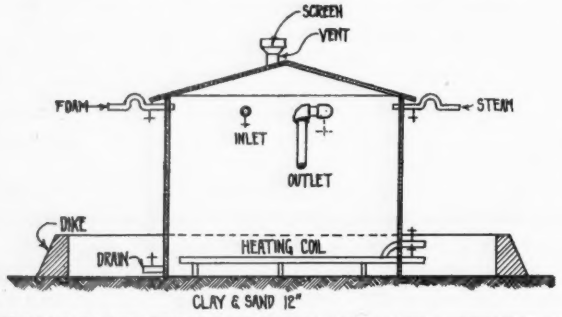
Yearly cost of operation is estimated at $232,411, made up of; coal cost, $164,250; labor, $12,316; maintenance, taxes and royalties, $24,345; interest, sinking fund and depreciation, $31,500. Income is estimated as $232,695, of this $42,187 is for the gas at 18 cents per B.t.u.; $53,379 is for the oils; $8879 is for sulphate of ammonia; $128,250 for the smokeless fuel of which 20,000 T. would be produced at $6.40 a ton. The Glasgow Works is owned by the city and no attempt is made to produce a profit.

Storing and Handling Fuel Oil

Design and Installation of Tanks, Connections Needed, Precautions to Be Taken and Hazards Involved

IN A PAPER presented before the American Society of Mechanical Engineers, Messrs. C. G. Sheffield and H. H. Fleming dealt with the practical problems of storing and handling oil for fuel in land burning installations. Comparing steel and concrete for tanks, the steel is found more satisfactory, especially for the lighter oils, on account of lower first cost and freedom from liability to crack. Underground storage has an advantage from fire hazard, but a steel tank above ground is more readily inspected, kept cleaned and in repair and drained. It is also free from the danger of being floated or collapsed by pressure of the underground water.

For cold weather handling, it is generally necessary to provide heating coils in the tanks, the heating, according to Underwriters rules being to not over 40 deg. below the flash point. It is found, however, that this is often not sufficient and that the temperature must be carried higher to get free flow of the oil in the pipes. For small tanks, a flat coil covering the entire bottom of the tank is used,



STORAGE TANKS SHOULD BE DIKED AND HAVE CONNECTIONS PROPERLY PLACED AND VALVED

supported on a wooden framework so that the condensation will drain toward the outlet. For large tanks, a box type coil is used, surrounding the suction pipe to the discharge pump.

Tanks Should Be Ample

Tank cars are in sizes from 6000 to 12,600 gal. capacity and it is necessary to have tank capacity to take more than the minimum car, as it is often not possible to get one of the smaller cars when the supply needs to be renewed. Storage should be divided into at least two tanks so that one can be cleaned and repaired while the other is in service, also, in case of fire, the oil can be pumped from the burning tank into the other.

If a tank is to be placed directly on the ground, it is important to excavate until a firm bearing is reached, taking away the loose top soil. The top 8 to 12 in. under the tank should be clay loam or a mixture of sand and clay and should rest on either all cut or all fill so that the settling will be even. If part cut and part fill is unavoidable, the fill should be made higher than the bottom of the cut to allow for extra settling. Location must be so chosen that there is room around each tank for a dike which will hold the full capacity of the tank, better 1½ times that capacity. Provision must be made to prevent washing away of fill or dike by rain. Where the soil is soft or uneven, it is better to use piling to support the tanks, capping these with a concrete slab having a ring at the outer edge. The slab should be covered with a cushion of sand or clay.

In building up a tank, the bottom and lowest ring should be built on horses and then tested by water pressure to make sure that all joints are tight. Seams should be calked with a round-nosed tool and, after all is tight, the bottom should be painted with asphaltic or graphite paint. The part of the tank completed can then be let down onto the foundation, care being taken to avoid strains which might open the joints. The remainder of the tank can then be built up in place, driving all rivets of ½ in. diameter or larger hot.

Connections Needed

Connections should be provided for inlet and outlet, for drainage of water and sediment, for heating coil inlet and outlet, for roof vent and for steam and foam fire-extinguishing lines. For the outlet a swinging suction is usually used, a two-elbow joint allowing the inlet end of the suction pipe to be held at any level by means of a cable through the roof of the tank. Steam lines are brought through the top ring with a goose neck higher than the top of the tank so that oil cannot flow into the steam line when the tank is filled. Vents should be of such size as will carry away air at the greatest rate that it can be displaced by the filling pumps, also so that it will not let pressure accumulate when the steam lines are opened full. To prevent outside fire from flashing back through the vents, the ends are covered with a screen of not coarser than 40 mesh, the diameter being increased so that the actual area of the openings is 25 per cent greater than the area of the vent pipe. These screens will corrode and clog quite rapidly, hence should be frequently inspected and cleaned or replaced.

Equipment of Pipe Lines

Lines running through the shell of the tank should have valves close to the tank to shut off in case of emergency. Filling or discharge pumps should be valved on both suction and discharge sides and filling pumps should have a check valve on the tank side to prevent oil flowing back to the pumps. If long lines which run above ground are left filled with oil, with valves closed at both ends of the line, the heat of the sun may expand the oil so that it will be forced out through the joints. It is necessary to see that such lines are drained, are never wholly closed or are provided with a relief valve. For unloading cars by gravity flow, a 10-in. line should be provided, as a 3 or 4-in. flexible connection will increase the unloading time 6 to 8 times. Since cars are usually provided with steam heating coils for cold weather unloading and steam connection must be carried to the cars, it is better to install a small duplex steam pump for unloading, using the exhaust steam for heating the oil.

After unloading is completed, all lines should be drained or blown clear with steam so that difficulty will not be encountered when using them again. Water and sediment should be drawn off regularly and the tanks kept clean. When cleaning tanks, the oil should be drawn out,

the manhole covers removed and the tank steamed out until no traces of oil vapor remain.

Fire Hazard from Oil

Hazards of oil burning were discussed in a paper before the Society by H. E. Newell. Standard flash point, as adopted by the Underwriters and various shipping boards, is 150 deg. F., which bars the use of crudes. This is considered an advantage since the dangerous volatile parts are removed by the topping process and much of the water and sediment is also taken out by the treatment preliminary to topping. The use of untopped oils is allowed only when a plant is specially equipped to handle them. For storage, Mr. Newell favors underground tanks outside buildings. If inside tanks are used, they should be surrounded by a concrete structure with an insulating layer of sand between the tanks and the concrete as a protection against falling walls and heating from outside in case of fire.

Outside tanks above ground should be of all steel, well grounded and with a surrounding dike for each tank having a capacity 1½ times that of the tank.

In providing vents, it is important to allow for carrying away all vapor that may be formed from the oil due to exposure to external fire so that there will be no danger of blowing off the roof. Data is not sufficient to formulate rules in regard to the size of vents and screens but it has been found that a 40-mesh screen works well for small pipes but is not good for larger ones.

For systems carrying 100 lb. or less pressure, standard iron or steel pipe is satisfactory; if the pressure is greater, extra heavy pipe and fittings should be used. In all cases the piping should be run as direct as possible, without sags, and pitched to drain to the storage tank without the use of traps. Provision must be made for expansion and to prevent vibration which might loosen the joints. Test should be at 50 per cent higher pressure than is to be carried on the line but in no case for less than 150 lb. Connections for oil should be made to the top of the tank, piping being preferably carried underground in a trench with cover and with no other pipes in the trench except steam lines. If carried underneath buildings, the oil pipe should be placed in a larger pipe, which has both ends open for drainage. Piping should be arranged so that flow can be stopped in case of injury with a valve on the supply line from each tank and one on the main line. Oil pumps should be arranged so that they may be shut down without entering the burner room or else by means of remote control. It is better to drive pump and blower from the same shaft so that both may be shut down together. Strainers of 8 mesh should be provided in the filling and discharge lines and should be cleaned every day or oftener. A gage with a three-way cock to show the pressure on either side of the strainer will show when the flow is being retarded.

Piping above the ground or floor, especially risers leading to furnaces, should be jacketed or otherwise protected from injury. Bypass piping should be provided around each supply pump so that the piping can be drained to the tank.

Burners should be of such type that it is impossible to enlarge the orifice, unless mechanical atomization is used. Also it should be impossible to unscrew and remove the needle valve while the burner is in operation. As soon as a burner gives evidence of becoming dirty, it should be removed, soaked in kerosene and all parts thoroughly cleaned.

When starting up a plant, new or after an idle period, blow out all lines with air; clean all strainers and replace any which are defective. See that any chambers on the oil lines are properly charged with air. Close individual control valves to all burners and open valves in pump suction lines. Start blowers and make sure that they are working properly. Pumps may now be started and oil brought up to the burners.

Make sure that stack dampers are open and all vents clear before starting a fire. In lighting, use a hand torch, a rigid wire or rod some 3 ft. long with a few strands of asbestos wound on the end, which may be dipped in oil. Stand well away from the burner in order to avoid a flare back. In no case should attempt be made to light a burner from the incandescent brick work.

Precautions to prevent flarebacks are: Prevent oil accumulating on the furnace floor; keep burner control valves tight at all times but, if any oil does get into the furnace, wipe up the floor and blow out the furnace with air before attempting to start up a burner; always use a torch when lighting a burner. If a flareback occurs, close the master valve, shutting off all oil to the furnace; speed up the blowers, if in operation, and shut down the oil pumps.

Every member of the boiler house force should be fully acquainted with every detail of the installation, should understand the purpose and operation of each piece and part of the apparatus and should know the location and purpose of all valves so well that he can manipulate them when the room is dark.

110,000-V. Underground Cable

Preparing for the erection of more centrally located generating stations, underground cable capable of operating at 110,000 v. and higher is being developed by the General Electric Co.

The nearest approach to this voltage is the 66,000 v. cable now in operation on the system of the Cleveland Electric Illuminating Co. A field test, conducted with a 200-ft. length of single conductor cable, has shown no development of trouble in a period of over five weeks. The cable is connected through a separate oil switch outside of the lightning arresters of the North Albany station of the Adirondack Power & Light Corp., and is subject to all of the surges, overvoltage stresses, etc., which might occur on the system proper.

Transmission lines of very high voltage cannot be taken into cities by overhead systems. It has therefore been necessary in the past to stop the high voltage transmission on the outskirts of cities, with the distribution center usually remote from the consumption center. The new cable makes it possible to carry the high voltage underground to the heart of the city if necessary. This test length of cable has a core of stranded copper wire, wrapped in oil saturated paper insulation, and enclosed in lead sheathing.

Importance of keeping acid or acid fumes away from wire rope cannot be over-emphasized. The slightest trace of acid coming in contact with wire rope is quite likely to damage it at that particular point, and oftentimes rope which gives way at one point has been acid damaged.

Precautions for Starting New Equipment

No Machine Can Be Expected to Operate Satisfactorily Unless Care and Common Sense Are Used in Starting It Up

WHEN STARTING up a new engine the supply pipe should first be thoroughly heated up and the condensate drained from it. When the unit is thoroughly warmed up, adjust the oil feeders and give the force feed pump several turns by hand and open the oil cups. Place the engine just beyond dead center, and open the bypass valve a little. The engine should be run slowly for half an hour or more while the oil feeds are adjusted and the bearings inspected to see that they are not heating up. Then the engine may be gradually speeded up by slowly opening the throttle valve.

Leave the drains open until it is certain that all moisture and water in the lines have been worked out. See that the traps on the separator and cylinder heads are working properly. After the unit has gained full speed and the governor has taken hold, the throttle valve may be opened wide and the load applied.

Lubrication of the cylinder is an important matter with any engine and in starting up a new engine the cylinder should have plenty of oil for several days. After a week or more of operation, the feed can be gradually cut down, the engineer using discretion in reducing the feed. It is much cheaper to use a little more oil the first few weeks of operation than to have trouble with a scored cylinder.

In placing a newly installed turbine in operation or in starting up a newly overhauled old unit, proceed slowly and make sure that everything is functioning properly as you go along. Enough help should be available so that the various parts of the installation, such as the condenser with its auxiliaries, the switchboard, driven machine, lubrication system, etc., may all be observed simultaneously. Under no circumstances should a machine be started up and adjusted for the first time without having a man at the throttle valve at all times and without making it the sole duty of another man to keep a constant watch on the speed of the machine with a direct reading tachometer.

The following precautions should be taken:

1. If the unit operates condensing lubricate the condenser auxiliaries, turn on such gland sealing water and cooling water as may be required for these auxiliaries, start the condenser auxiliaries and build up a vacuum.

2. Open all drains and make sure that all accumulated water is removed from the steam and exhaust lines and from the casing.

3. Start the auxiliary oil pump, if unit makes use of one, and see that all bearings are being supplied with oil from it.

4. Turn on the oil cooling water.

5. Open the exhaust shut-off valve and seal the glands or end packing cases if unit is to operate condensing.

6. Open the throttle valve slightly and run the unit slowly alone, the coupling pins having been previously removed.

7. Couple up the driven machine and bring the machine slowly up to speed. Observe whether main oil pump picks up its oil and maintains a pressure.

8. Operate the unit for an hour or so and then shut down, check alinement and if found correct, carefully dowel the unit.

Put the load on the unit gradually and observe the governor action. Make any governor adjustments necessary and run the unit under load for 4 or 5 hr.

10. After the trial run shut down the unit, correct any minor details which may need attention and inspect the bearings.

After starting up and during regular operation, the unit itself will require but little attention. There are several features, however, which should be made the subjects of careful inspection by the watch engineer at short intervals throughout the run. The temperatures of the main bearings and of the thrust bearing, also the amount of oil being received by them, should be observed at reasonable intervals. Any excessive rise in temperature above normal indicates that something is wrong. The oil may be dirty or mixed with water, the cooling water may be wholly or partially shut off or too high in temperature, the pipes may be clogged so as to prevent sufficient oil reaching the bearings, or the driven machine, through improper conditions, may be imposing a heavy thrust on the thrust bearing.

Observe the smoothness of operation. Any vibration, either periodical or constantly increasing, should be investigated and the difficulty immediately corrected. Some of the causes of vibration are misalinement, worn bearings, lack of oil on the bearings, water in the turbine casing and improper setting of the rotor clearance. Inspect all drain traps and devices regularly during the run to make sure that they are working properly and that water is not being carried into the turbine in "slugs" and that it is not accumulated in the turbine casing or exhaust line.

Centrifugal pumps should never be started before they are thoroughly primed. The pump can be primed by exhausting the air from the pump and suction piping, which is easily accomplished by means of a suitable ejector, connected to top of pump case cover. On a multi-stage pump, the ejector should be connected to the first stage and the other stages should be provided with air cocks to relieve the pump of air after being started. When priming the pump, the gate valve in the discharge line near the pump should be closed.

Another way of priming the pump is to fill the pump case and suction piping with water, either from the discharge main or from some outside source. In this case, however, a foot valve is necessary on the end of the suction piping. When priming by this method, air cocks should be placed on top of pump case cover and at a higher point in the discharge pipe below check or gate valve and these air cocks should be left open until all air is expelled.

Before starting, clean out oil reservoirs and bearings thoroughly and fill the reservoirs with a good quality of light mineral oil. Make sure that the oil level is high enough to submerge the oil rings sufficiently. Before the coupling bolts are put in, see that the pump shaft can be revolved freely and test out rotation of motor to see that it is the same as indicated by an arrow on the periphery of the coupling.

Features of Airless Injection Oil Engines---IV*

FUEL OIL DISTRIBUTION IN COMBUSTION CHAMBER AND DIRECTED TURBULENCE ARE FEATURES OF HESSELMAN'S SYSTEM. BY H. F. BIRNIE AND R. C. BAUMANN

HESSELMAN'S system, incorporates several special features. The most striking of all is probably the care which is taken to distribute the fuel oil into the combustion chamber and to give the air charge a directed turbulence.

Figure 1 represents the patent drawing taken in Stockholm in 1923 and shows the diagram of fuel sprays in the combustion space. The air inlet valve is provided with a shield (80) which causes the air to enter in a tangential direction thereby giving the supply a rotary movement. The nozzle of the fuel valve has five openings on each side of the center line. The combustion space is considered as being divided in a number of parts of equal capacity with a common apex (0) situated in the nozzle

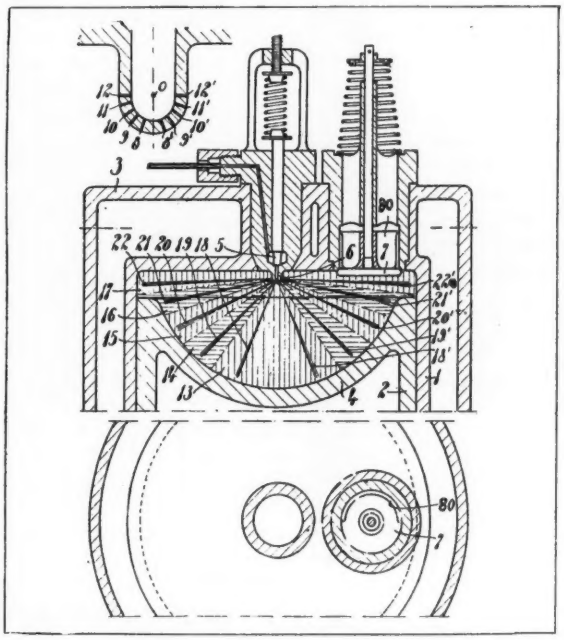


FIG. 1. FIRST ARRANGEMENT OF HESSELMAN'S FUEL AND INLET VALVES

tip. The fuel sprays going in the combustion space through the drillings 8-12 and 8'-12' are theoretically supposed to come into contact with imaginary cones having the same air content. These cones are represented by alternating vertical and horizontal lines marked 13-17. So as to bring all the available air into contact with the sprays, the air has thus to be given a rotary motion. This is, as stated, accomplished by fitting a shield at the inlet valve and, as the air rushes in the cylinder during the suction stroke, it is deflected in a direction tangent to the cylinder circumference. During the compression stroke, this motion does not encounter any obstacle and only the friction against the walls will tend to dampen it. The shape and area of the shield has to be determined by experiments, and it was found that with the minimum shroud the fuel consumption was 30 per cent above the best result and 15 per cent above this minimum when the shield gave the highest obtainable rotary velocity.

Figure 2 shows another shape of the combustion chamber which was supposedly finally adopted. The disposition of the fuel sprays was accordingly changed to suit the new layout. It will be noticed that the shroud is fitted inside the suction valve as marked by (80) on the elevation in Fig. 1. Plan at X (Fig. 2) illustrates also how the position of the shroud can be shifted around the intake valve axis. During the tests it was observed that the timing of the ignition was not affected by varying the

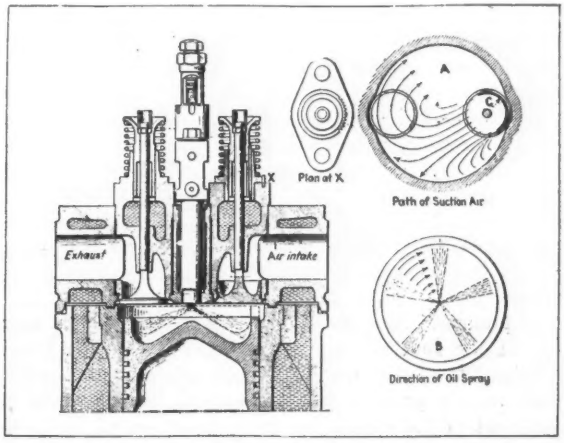


FIG. 2. LATER ARRANGEMENT OF FUEL AND INLET VALVES

intensity of the air motion, though it did change the shape of the expansion line on the indicator diagrams. This observation can be explained by the assumption that the air velocity was not as considerable as was surmised. There is no doubt that if this turbulence had been as great as is obtained with a Price combustion chamber the ignition would have been almost instantaneous instead of gradual as shown on the indicator diagrams of the engine (see Fig. 9).

It was also observed in the Hesselman engine that the higher air velocity caused a rapid fall of the expansion line even before the injection had ceased, this fact being probably due to the higher air velocity bringing the burning gases into contact with the cold cylinder walls. This assumption would be corroborated by the fuel consumption tests which showed that the maximum efficiency did not fall together with the greatest air whirling intensity. In other words, the best economy will be obtained with a turbulence that is of such intensity that the fuel comes in contact with all the air it needs for combustion without unduly cooling the burning gases through contact with the cold water cooled surfaces of the cylinder.

Figure 3 shows a design suggested for converting ordinary oil engine to the Hesselman System. This change means:

1. Fitting on the old engine of a new fuel pump with its driving cam and arrangement for the variation of the plunger speed. 2. Installation of a new governor connection. 3. Setting of cam driven fuel oil distributors. 4. Use of a high pressure differential valve. 5. Adjusting

*Part I appeared in the July 15 issue, Part II in the October 15 issue and Part III in the November 15 issue.

of one or two high pressure fuel filters. 6. Modifying the shape of the combustion chamber. 7. Adding a shield to the inlet valve. 8. Providing for an auxiliary fuel feed pump to force the combustible through the high pressure filter situated on the fuel line to the fuel pump.

The layout comprises a fuel pump driven by a cam on the vertical shaft. The pump in itself presents no unusual features having a ground-in plunger, a suction valve acting also as bypass valve and a discharge valve. A special arrangement permits a lever to vary the speed of

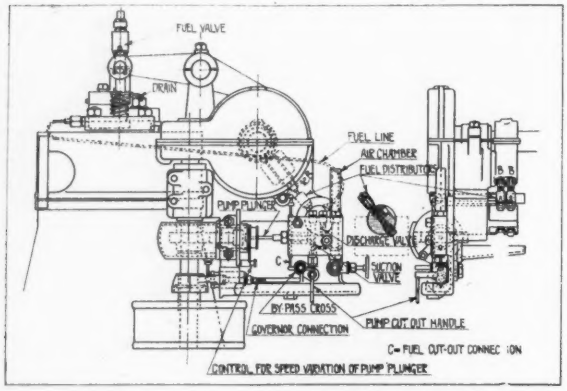


FIG. 3. APPLICATION OF THE HESSELMAN SYSTEM TO AN ENGINE

this plunger. A higher speed means an earlier opening of the fuel valve, a higher pressure in the line, a greater lift of the fuel valve and a better atomization. This feature presents an improvement, as it permits adjustment of the engine for small variations of fuel, temperature speed, etc. Load variations are taken care of by the governor through a cross which lifts the suction valve of the fuel pump. The rod which acts on the third

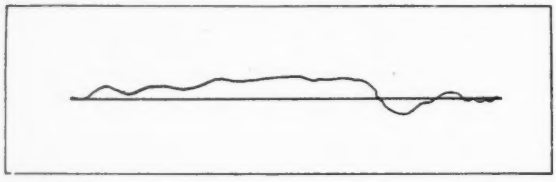


FIG. 4. PRESSURE RELIEF CAUSED BY MOVEMENT OF DISTRIBUTORS

arm of the cross permits cutting off the fuel of a cylinder by the action of the pin B fitted on the distributor, and which pushes the rod down every time that the distributor opens, keeping the suction valve open during the discharge stroke of the fuel pump.

From the pump plunger, the combustible passes through a discharge valve and thence to the distributors. These distributors are driven by cams on the camshaft and keep open a small check valve during the fuel delivery stroke, allowing the combustible to go to the fuel valve of each respective cylinder. There are as many distributors as power cylinders. When the distributor recedes, it creates an additional volume permitting the fuel oil to expand and relieving the pressure on the fuel needle seat. This pressure relief in the line from the distributor to the spray nozzles is shown graphically by Fig. 4. The base line is set at a pressure of 3550 lb. per sq. in. The rise above the base line represents 355 lb. per sq. in.

From the distributor the fuel goes to the fuel valve. This valve is shown in detail in Fig. 5. Its chief claim for originality lies in its spring which is made up by disk elements fitted together, giving for its size a very great stiffness (3500 lb. per sq. in. for 1.25 in. outside diameter). The compression of the spring is adjustable by means of a nut. The spindle of the valve acts only as guide and is not moved when the valve opens.

A high pressure fuel filter precedes the valve and holds all particles bigger than 0.001 in. It comprises a solid cylinder fitting very closely in the casing. The fuel, before it can reach the fuel valve has to pass through the clearance between cylinder and casing so as to pass from one of the longitudinal grooves to the other. A similar filter is fitted to the fuel pump and it requires a special

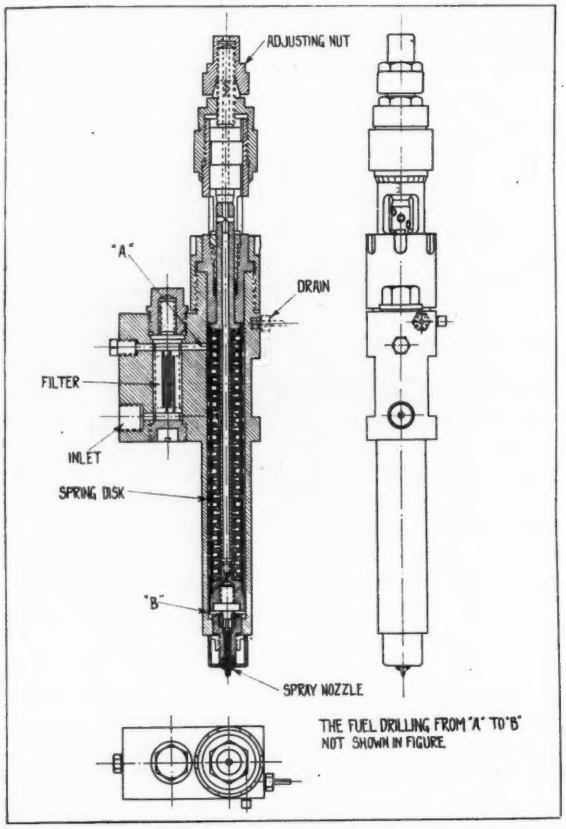


FIG. 5. FUEL VALVE SPRING IS MADE UP OF DISK ELEMENTS

feed pump to force the combustible from the supply to the suction valve. Hesselman's fuel valve is like Scott-Still's of the differential type. Its opening in Hesselman's design is not exceedingly rapid, as the additional surface which comes under action of the fuel pressure when the valve is lifted is small compared to the initial surface. Its closing is quick, as shown in Fig. 4. From this figure it is to be seen that the lift varies proportionally to the load carried by the engine.

Figure 6B shows a bundle of offset diagrams taken while varying the pump plunger speed. The highest peak corresponds to the greatest speed because, as mentioned previously, a greater plunger velocity will cause an earlier lead, a better atomization and a greater valve lift.

On the experimental engine on which the different indicator cards were taken, it was possible to vary the

lead of the fuel injection. Figure 6C shows, as would be expected, that the smaller lead corresponds to the lowest peak and the highest exhaust pressure.

Figure 7 is a full load card with a maximum peak of 578 lb. (Compression 388 lb. per sq. in.); the brake mean effective pressure being 76 lb. per sq. in. The combustion cycle is a mixture of Otto and Diesel cycle, which seems to give on solid injection engine the best results.

All the data obtained with Hesselman's injection system, were taken on a two cylinder experimental engine (bore 10 in.; stroke 14.5 in.; 300 r.p.m.; full load rating 65 b.hp.). The results obtained on the test stand are rather promising as an overload of 37 per cent has been obtained with perfectly clear exhaust. The fuel readings were as low as .38 lb. fuel per b.hp.-hr.

Whether or not the system will be used on bigger engines is not known. It seems that one firm in Germany and another in Austria are making experiments with it.

Further development will be followed with interest. The most original feature of the system remains undoubtedly the directed turbulence of the air charge. Figure 2 shows how the shield can be turned around so as to vary the direction of the intake air rushing into the cylinder.

On four cycle engines, the drive of the fuel pump plunger must be at half engine speed. The means adopted by Hesselman to use only one plunger to serve all the cylinders seems to give in practice very good results. One American firm is using this arrangement but, instead of controlling the distribution of the fuel by cam-driven plungers, has adopted a rotary distributor with the best results, in conjunction with lightly loaded spray valves.

Whether the pressure relief in the fuel line from the distributors to the nozzle from 3000 to 3500 lb. is the best solution might be doubted, for the following reasons: Due to the bypassing system, which consists in lifting the pump suction valve, the pump discharge valve closes as soon as the suction valve lifts, thereby maintaining a pressure of about 3500 lb. in the fuel line from the pump to the nozzle. In other words, when the pump plunger makes its delivery stroke it has to compress the volume of fuel in the pump body to about 3500 lb. from atmospheric (or nearly so) before it opens the discharge valve. This volume being generally small, the fuel compression volume will be taken up soon after the plunger begins to move.

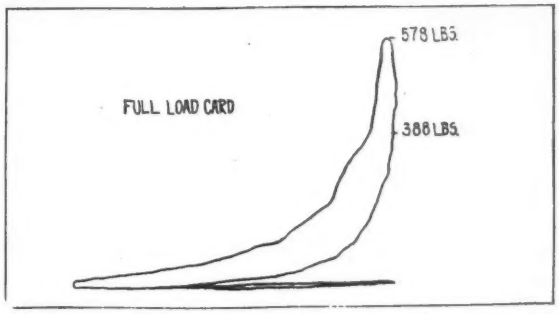


FIG. 7. FULL LOAD CARD WITH MAXIMUM PEAK OF 578 LB.

So as to prevent any jarring of the pump, the camrise has to be gradual; that is, the plunger cannot be accelerated too quickly so as not to produce a hammer blow which would occur if the plunger were moved abruptly against this heavy pressure. This condition can be obviated by making the pump plunger diameter small and its stroke long, thereby giving a rather slow opening of the fuel valve; or by relieving to atmospheric (as in the Scott-Still engine) the oil pressure in the whole fuel line from the pump to the nozzle.

Figure 6 shows how the fuel needle lift varies with the load of the engine, as in the solid injection engines using the Vicker's common rail system. The highest lift corresponds, of course, to the greater fuel pressure in the line. It illustrates the action of the fuel cam, showing how the pump plunger is, at first, slowly accelerated, creating a pressure but a little higher than the pressure required to open the valve, and gradually increasing the pressure difference, causing a greater opening. The construction of the fuel needle end does not give very much additional surface for the oil pressure to act upon, when the valve is open. A quicker opening could be obtained by making this difference in area bigger, but it would remain to be seen whether this would be favorable to the Hesselman engine. In any case, it would give less friction losses and hence less pressure drop between the needle end and the spray tip. On the other hand, it would lower the closing pressure.

Scott-Still's method of relieving the fuel pressure to atmospheric seems to be more favorable, as it permits the first part of the fuel cam to be used to compress the fuel to the opening pressure of the fuel valve. This allows the

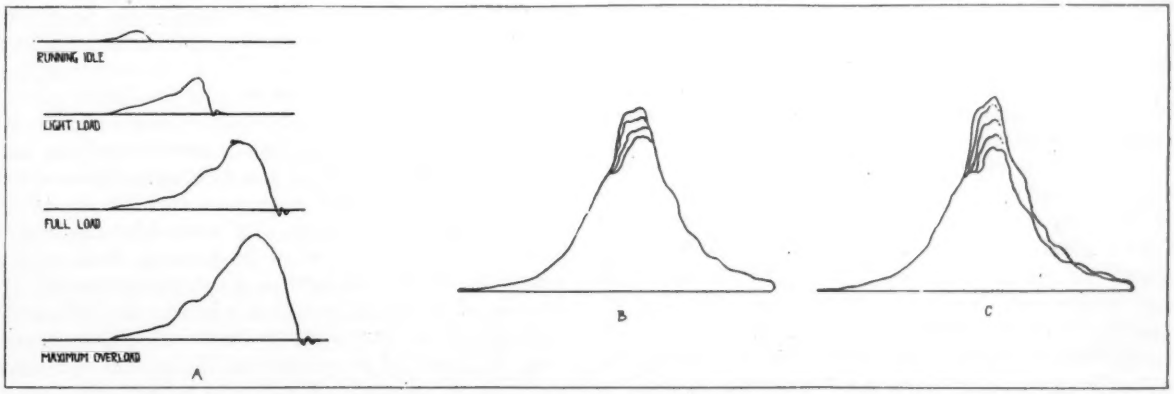


FIG. 6. VARIATION OF NEEDLE LIFT, PUMP PLUNGER SPEED AND EFFECT OF FUEL INJECTION LEAD

A. Fuel needle lift varies with the load on the engine and the highest lift corresponds to the greatest fuel pressure in the line. B. Offset diagrams taken while varying the pump plunger speed. The highest peak corresponds to the greatest speed because greater plunger velocity causes earlier lead and greater valve lift. C. Similar to diagrams shown in B but with lead of fuel injection varied.

pump plunger to be slowly accelerated preventing pump vibrations, and to be in rapid motion when the fuel valve begins to open, consequently fostering a quick lift of the valve needle. It will be noticed on Fig. 3 that there is an air chamber in the fuel line to the pump just before the suction valve. The fact that the latter is used for by-passing makes this necessary to prevent undesirable disturbances in the combustible flowing to the pump.

Hesselman's system has been developed after careful study of all the factors required for the design of a solid injection engine. There might, as yet, be a divergence of opinion in regards of the solution adopted, but summing up, one sees that the following points have been covered. 1. The fuel oil should be free of all foreign matter tending to obstruct the spray nozzle openings. The high pressure filters adopted show the care taken to filter the fuel. The great resistance offered by such filters is not very attractive and the complication of an auxiliary fuel pump to force the oil to its point of delivery seems rather cumbersome. 2. A high grade of atomization should be maintained during the whole fuel injection period, a fact which is taken care of by the differential valve. 3. Distribution of the fuel oil in the combustion space is carefully laid out. 4. Air turbulence bringing all the oxygen to the burning sprays can be regulated at will and permits the creation of ideal conditions for perfect combustion.

Identification Markings for Pipes

PROGRESS BEING made towards a code for the identification of piping systems is indicated in a recent report by a sectional committee organized under the rules of the American Engineering Standards Committee. This committee submits the following report, the conclusions for which were arrived at from field investigations and personal interviews with operators and designers of power and industrial plants and also from articles appearing in the technical press. An attempt was also made to discover the methods of pipe line identification employed in the foreign field and it was found that practically no attention has been given to the question of pipe markings and where paint is employed its application is intended as a protection for the pipe covering material rather than as a means of determining the nature of the fluid flowing through the lines.

It was first thought that the work of the committee should supplement the report of the sub-committee on identification by color, but as this report deals with identification by markings, it apparently becomes a separate phase of the subject.

First efforts of the committee centered upon a combination of symbols along with a legend naming the nature of the containing fluid, the legend with its accompanying symbol appearing prominently at the points of supply to the piping system and at points of distribution therefrom; any further marking at intermediate points along the pipe line to consist of the symbol only. This idea was discarded because of the great mass of detail involved, the difficulty an operating force would encounter in recalling to mind the different shapes and forms and the probable necessity for the publishing of a code book upon the part of each operating company.

It has therefore been recommended that the form of identification marking shall consist principally of a lettered legend, abbreviated or otherwise, naming the material carried in the pipe line. Where a knowledge of the direction of fluid flow may be of service, it is suggested that arrows be painted on the pipe.

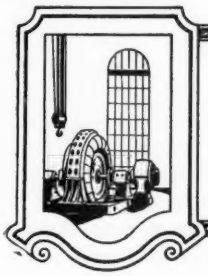
Attention has been given to the question of visibility with reference to pipe markings and this committee recommends that where pipe lines are located some distance above the normal line of the operator's vision, the lettering be placed below the horizontal center line of the pipe. It is desirable, where the view is obstructed, that the lettering employed be stenciled on the two lower quarters of the pipe covering rather than one side only. The lettering in this position will be less liable to be obscured by dust collection or mechanical damage.

In certain types of plants it may be desirable to label the pipes at junction points or points of distribution only. In certain existing power plants the markings are repeated at intervals all along the pipe line. In any case, the operating man should decide the location and number of signs required in each particular system of piping.

Regarding the type and size of letters and numbers, the committee recommends the use of stencils of standard sizes, easily obtained from any stencil manufacturer, the stencils to range in height from ½ in. to 3½ in. For pipes smaller than ¾ in. in diameter requiring identifying marks, a metal tag with the lettering etched and filled in with enamel may be used.

With regard to visibility, the eye as a matter of habit, is most accustomed to the reading of black letters on lighter backgrounds and investigations in plants of different kinds has disclosed the fact that a large number of signs and other designations are made with black letters on a background of aluminum paint. Vehicles have been developed which with aluminum powder make a paint which will stand up under temperatures from 700 to 900 deg. F., without the loss in color or adherence. Black letters can be either painted or stenciled on a rectangular background of aluminum paint. The committee on Plan and Scope has already reported in favor of the use of aluminum paint for use on lines carrying extra valuable materials but it is felt that this fact need not exclude its use as a background for the proposed lettering.

ONE OF the most important factors in connection with the installation of a centrifugal pump, is the proper arrangement and size of the suction and discharge piping. Particular attention should be given to the suction piping, which should be as short and have as few bends and fittings as possible. Short radius elbows and ordinary tees should be avoided. Special fittings should always be used to avoid sudden changes in the direction of flow of the water. An elbow should never be bolted directly to the suction flange of the pump, but a straight nipple of a length approximately equal to the diameter of the suction opening should be used between the pump and the fittings. The size of the piping should as a rule be larger than the openings of the pump. As to the velocity, this depends upon the length of the piping and the amount of friction which can be allowed. A safe rule for both suction and discharge piping is to keep the velocity below 6 ft. per sec. Short lines may safely be installed for a velocity of 8 ft. per sec.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of Converting Apparatus---V

MAINTENANCE OF ROTARY CONVERTERS. SPARKING AND FLASHOVERS.

BY V. E. JOHNSON

IN COMMON with all machines which have commutators, rotary converters require careful adjustment of the brushes. The adjustments are broadly placed in four divisions:

a. Adjustment of brush tension.
b. Proper spacing, so as to make all brush studs equidistant.
c. Proper setting with regard to neutral. This is especially important in machines having commutating poles.
d. Sanding in.

In any machine the amount of spring tension required is determined largely by the quality of brush used and this in turn is determined at the factory by careful and exhaustive tests. The softer brushes, which have considerable graphite in them should have about 1 lb. to the square inch of commutator contact, while the harder and more abrasive ones require about 2 lb. This tension should be determined by means of a small spring balance and the reading taken at the point where the brush just leaves the surface of the commutator. If the reading is taken at a "higher" point the result will be inaccurate as the spring tension increases as the brush is pulled higher.

It may not be necessary to test every brush with the balance, as a close approximation can be obtained by feeling alone—after one or two have been adjusted as a standard to go by; however, if commutating difficulties are encountered, it may be worth while to test every brush so that every one will be compelled to carry its share of the current. This is particularly the case when the contact surface and cross section is small, so that every portion must work at a maximum.

SPACING

Each stud must be so located, that all its brushes rest on the same bar. This is a matter of machine work at the factory, and should require no adjustment in the field. If correction is found to be necessary, the simplest remedy is the interposition of shims between the brush holder arms and the rocker ring.

The brushes must be equally spaced around the commutator. This can be done by two means, the choice between them depending somewhat on local conditions. The simpler way consists of counting the commutator bars, and spacing the brushes 1/n of the number, where n is the number of studs. In using this method, the toe of the brushes should be set on a mica segment, so that the spacing may be accurate. If the brushes are old or irregular, or if they are loose in the holders, this method may not be sufficiently accurate. By removing a brush on each stud and inserting a steel scale or straightedge, a more accurate check can be obtained.

The second method employs a strip of paper about an inch wide, and of sufficient length to reach around the commutator. This is wrapped around the latter, and the point of overlapping marked, so that upon removing, the exact circumference is laid off. This distance is divided into n equal spaces, either by folding or by measuring, and every division marked with a sharp pencil. The strip is then placed around the commutator again, with one mark under a stud taken as a starting point. The toe of the brush may be used to find the exact location, and if this is impossible due to irregularity a straightedge should be used. Care must be taken that the strip of paper does not slip around the commutator. The other studs are then set on the points that were marked off. After this setting has been finished as accurately as possible, a new strip should be used for a final check.

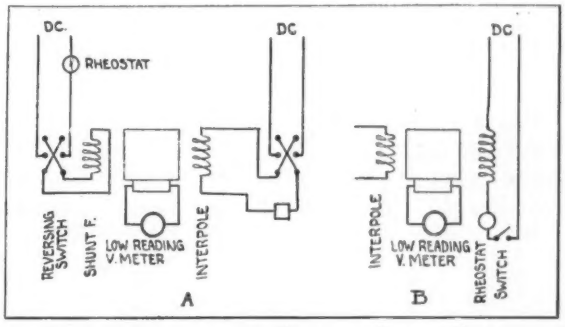


FIG. 1. CONNECTIONS FOR "RUNNING" AND "STANDING" TESTS

SETTING WITH REGARD TO NEUTRAL

It is necessary to know where the neutral point is, before brush setting can be intelligently undertaken. On commutating pole machines, this determination must be accurate, as many of these machines can operate at no other point. The neutral point can be determined by two general methods—commonly called the "running" and "standing" tests. The former is more accurate. If the neutral is determined by both schemes, it may be found that the points do not agree and in that event the running method is the one to be used. This discrepancy is usually very small, often only a small part of one bar.

The "running test" is performed as follows. After the studs have been spaced as above, all the brushes except one in each stud should be removed. These pilot brushes should be filed off so that they will make contact with about 1½ commutator bars—never more than two. Connections should then be made as in Fig. 1A. Run the machine at approximately normal speed by driving it from a separate motor. With both switches open, the voltmeter will read the residual in the main fields. By reversing the main field excitation and applying an extremely small current, this residual can be reduced to zero. This may require several reversals but the process should be continued until the low scale on the voltmeter gives no deflection.

An exceedingly small current should now be passed through the interpoles—say 1 or 2 per cent of normal current. If the brushes are exactly at neutral, there should be no voltage generated. If the voltmeter registers, the brush rigging should be shifted until the deflection drops to zero. At this point, open the interpole circuit and check the main fields for residual. Check with the interpoles in the opposite direction of flux flow and continue this process

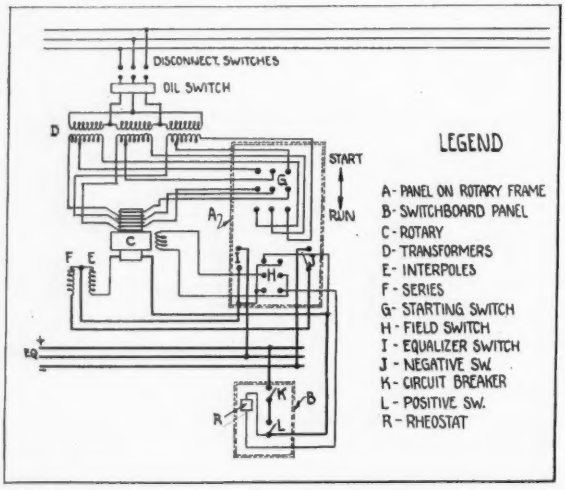


FIG. 2. TYPICAL CONNECTIONS FOR A ROTARY CONVERTER

until a point is found where the voltmeter reading is zero for either direction of magnetization. The residual of the main poles must be checked to see that it still is at zero. The point so obtained is neutral. The reading can be checked with a slightly stronger interpole field but if made too strong the flux from it gets into the main poles and makes it impossible to get any consistent results.

The "standing test" is made in the following manner and is simpler from the fact that it is not necessary to provide any means of running the rotary. Connections are made as in Fig. 1B. By opening and closing the switch a "voltage kick" will be observed on the voltmeter, and this will entirely disappear when the brushes have been placed in the neutral position. The brushes should all be removed except one pilot brush in each stud, and this should have its face sanded off so that it touches one bar only.

The machines are usually not shipped from the factory until the brush spacing and neutral point have been determined and mechanically fixed by means of dowel pins or other devices. It should not be necessary to perform either of the preceding two tests, on any new machine—but the information may have to be applied to the adjustment of old types.

Sanding In

In order that the brushes may be able to carry their full rated current, it is important that they are so sanded in as to make full contact when the machine is rotating in the proper direction. The preliminary sanding may be done by pulling a piece of heavy sand or garnet paper back and forth under the brushes—tension being as heavy as possible. The final fitting should be made with finer paper, pulled only in the direction of rotation.

It is desirable to bevel the tips of the brushes slightly, as this prevents portions of carbon from splintering off.

The brushes which rest on the rings are made from a combination of carbon, graphite and copper, which is given various trade names. These brushes are usually quite hard, and the process of grinding in tedious. They too should be fitted quite carefully, although the fine finish required on the direct current brushes is not needed.

In order to wear the commutator equally from end to end, and to prevent the formation of ridges it is necessary to use an end play device or oscillator, or else to use great care in placing the brushes. The latter method is getting to be quite a popular scheme as it eliminates some of the mechanical difficulties which the former had. This proper placing differs from the old-fashioned "staggering" in that it takes into consideration the fact that the wear under the two polarities is not the same. Therefore the "staggering" is carried out with reference to every other stud, instead of with every one as before.

A new machine frequently develops commutator troubles after having been in service for some time. This is due to the drying out or seasoning of the mica which forms the insulation between the bars. When this seasoning has produced loose bars, it is a waste of time to turn the commutator without first tightening it. Sometimes this tightening and turning must be repeated two or three times before the parts assume their permanent position. High mica results from either mushy mica which squeezes out from between the bars, or more commonly, because the copper wears faster than the insulation. This is remedied by using harder brushes, which grind off the mica, or if this is impossible due to other conditions, by undercutting the mica. The latter process must, however, be carefully done, special care being paid to the rounding off of the edges of the bars.

If the commutator is dirty, it may be cleaned by using sandpaper. Gummy deposits are sometimes caused by the use of too much oil and this condition should be avoided. A small amount of oil quickly applied, and wiped off with a coarse lintless cloth, helps to produce a finish on the copper, and does much to prevent annoying "squealing." Even so-called "lubricating brushes" may require the use of extra oil.

Sparking and Flash Overs

A well-designed machine should not spark. A new machine running with factory adjustment should commutate perfectly over its entire range. If it does not the following points should be checked and the remedies as indicated applied:

a. Brush setting, and spacing should be checked.
b. Brush setting with respect to neutral should be checked, if any possibility exists that the factory adjustment has been changed.
c. Brushes should be properly fitted, and should move freely in the holder.
d. Brush tension should be sufficient, and should be equal for all brushes.
e. Commutator should be true. If not it should be tightened, and turned or ground.
f. Mechanical vibration may cause sparking, and should be eliminated.
g. Wrong quality of brushes. This is an improbable reason, and would only occur when a change from the original type had been made.
h. Low a.c. voltage. This can be easily checked, and should be remedied.
i. There may be faulty connections in the armature, or errors in the design. Such troubles should be referred to the factory.

Some consideration has already been given to flashovers. If a machine persists in "going over," a preliminary check may reveal one of the following causes:

a. Poor commutation—caused by any of the previously enumerated faults.
b. Fluctuations in the supply circuits which set up surges in the feeders.
c. Too low resistance between point of frequent short circuits, and the d.c. buses.

If the difficulty persists it may be that the trouble is internal and caused by improper design or faulty construction. Tests should be made for shorts and grounds, and these eliminated. If the cause is still obscure, it would be advisable to call in a factory service man.

Figure 2 shows typical switchboard connections for a rotary converter.

Parallel Operation of Auxiliary Generators

NEW ARRANGEMENT CONSISTING OF SMALL AUXILIARY GENERATOR DIRECT CONNECTED TO MAIN UNIT PRESENTS NEW OPERATING PROBLEMS. BY H. B. SEELEY

DUE TO RECENT developments in methods of obtaining heat balance in power stations, the direct connections of auxiliary generators to shafts of the main units has come into use. While this method of obtaining power for the auxiliaries in a steam generating station shows some distinct advantages in economy over the older turbine driven house unit, the relative merits of the system will not be discussed in this article. The system was briefly discussed in an article by A. L. Penniman, Jr., in the April 1, 1924 issue of Power Plant Engineering, under the heading "Relation of Auxiliaries to Heat Balance."

With the use of these direct connected generators, a number of questions have come up, particularly in connection with their operation in parallel with other sources of auxiliary power. The following discussion will point out some of the conditions which arise when these units are paralleled, first, through transformers with the main generator; second, with existing turbine-driven house generators, and third, with other shaft generators. Some of the difficulties encountered, as well as some of the precautions to be taken when such operation is anticipated, are also brought out.

PARALLEL OPERATION WITH THE MAIN BUS THROUGH TRANSFORMERS

When shaft generators are used, it is usual to supply an alternate source of power by stepping down with transformers from the main bus. The essential auxiliaries are ordinarily supplied by the auxiliary generator, while less important motors may be supplied through the transformer from the main bus. In transferring motors from one bus to the other, it is sometimes desirable to parallel the two busses in order to transfer motors without shutting them down. Under proper conditions, as pointed out later, this can be done by means of a tie circuit breaker. Figure 1 shows a typical layout, with the auxiliary bus supplied from the shaft generator, together with a house transformer bus which receives power through a transformer bank from the main system. Each motor or group of motors has two circuit breakers, making it possible to connect to either bus. In addition, a tie circuit breaker is provided for paralleling the two busses.

CONDITIONS NECESSARY FOR PARALLEL OPERATION

To parallel the two busses without causing circulating currents to flow, the voltages of the two busses must be the same in both magnitude and phase. Since the main

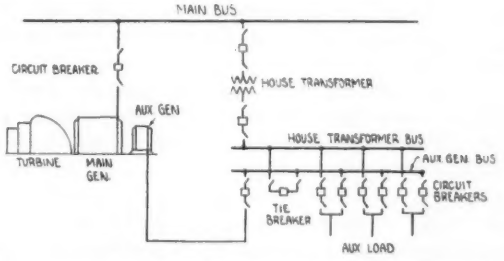


FIG. 1. AUXILIARY GENERATOR PARALLELED WITH MAIN BUS

and auxiliary generators are mechanically coupled and have the same number of poles, their frequencies will be the same. If the stator windings of both machines have their corresponding phases in the same relative position, and if the rotors are coupled together with no angular displacement between corresponding poles, the terminal voltages of the two machines at no load will be exactly in phase. If, as is generally the case, the transformer bus is supplied by a delta-delta connected transformer bank of the proper ratio, the two bus voltages at no load will be exactly the same in both magnitude and phase except for the possibility of a reversal of excitation, which would throw the voltages 180 deg. out of phase. After checking to see that the voltages are not 180 deg. out of phase, the tie circuit breaker may be closed without synchronizing. If, however, the stator windings of the two machines do not have corresponding phases in the same relative position, or if the rotors are coupled together with an angular displacement between corresponding poles, the two bus voltages will be

out of phase, so that closing the tie circuit breaker will cause circulating currents to flow.

Under some circumstances, the two busses may not be in phase even though both stator windings and rotors may be in the same relative position. In one particular case, a star-delta connected transformer bank was used to supply power from the main bus. It is well known that this connection produces a 30 deg. shift in the phase relation of the voltages. Fortunately in this particular case, it was found that the coupling between the rotors of the main and auxiliary generators could be shifted by 90-electrical degree steps. By connecting the small generator to the bus with a 120-deg. advance, and at the same time rotating the coupling of the small generator 90 electrical degrees in the direction of rotation, it was possible to obtain the required 30-deg. shift. If this condition is known

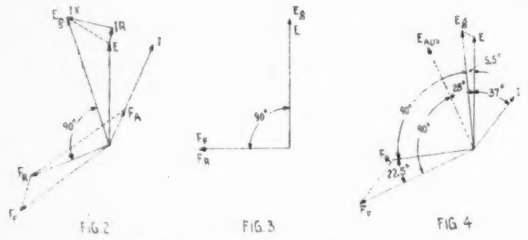


FIG. 2-4. VECTOR DIAGRAM SHOWING CURRENT AND VOLTAGE RELATIONS IN A SYNCHRONOUS GENERATOR UNDER VARIOUS CONDITIONS OF LOAD

before the machines are built, the proper angle between the main and auxiliary generator rotors can be taken care of by a proper arrangement in the coupling between the two generators.

It has been suggested that the auxiliary generator be provided with means for frame shifting, similar to that used for dividing the load between frequency-changer sets operated in parallel. With the proper amount of frame shifting, it would always be possible to bring the voltages into phase. Provision for shifting the frame on these house generators presents several complications. It would be necessary to have flexibility in the stator leads and, because the generator air intake is connected to permanent air ducts, special construction would be required in the end bells. If the necessary precautions are taken, the two bus voltages will be in phase or very nearly so without frame shifting, so that they may be paralleled temporarily at least, without injuring the apparatus. The following discussion of division of load between the main and auxiliary units when operated in parallel shows that the load carried by the small generator depends upon the loading of the main generator rather than upon the load taken from the auxiliary bus.

Conditions which obtain in a synchronous generator under loaded and unloaded conditions are illustrated in Figs. 2 and 3. Figure 2 is the diagram for a loaded generator. F_f represents the field ampere-turns of the generator. When a current I, is being taken from the generator, the armature produces a magneto-motive force F_a, in phase with I. This m.m.f. combines with the field to produce a resultant m.m.f. Fr. This resultant magnetomotive force produces the air gap flux. The voltage, Eg, generated in the armature lags behind the flux by 90 deg. The terminal voltage of the generator differs from its generated voltage by the amount of the armature resistance drop IR, and reactance drop, IX.

Conditions at no load are shown in Fig. 3. Since there is no armature magnetomotive force, F_r is equal to F_f and the air-gap flux is in phase with the generator field. Since there is no armature current, there can be no armature impedance drop and the terminal voltage will equal the generated voltage. At no load, therefore, the terminal voltage will lag behind the field by 90 deg.

When the generator is carrying a lagging load, the voltage is shifted to a position behind the no-load position. This change in the phase position of the voltage is caused by two factors, the angular displacement between the generated and terminal voltages due to armature impedance drop and the angular displacement between the main field and the air-gap flux caused by armature reaction. The actual angle of voltage shift from its no load position will depend upon the design of the machine and upon its field excitation, load and power-factor. The actual angle of shift for full-load 80 per cent power-factor varies between 25 and 30 electrical degrees for turbogenerators. The small auxiliary generators usually have prac-

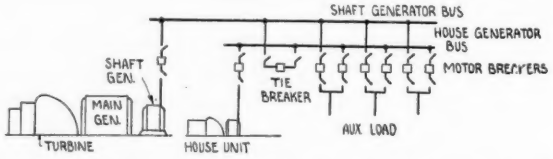


FIG. 5. AUXILIARY GENERATOR PARALLELED WITH HOUSE UNIT

tically the same displacement angle from no load to full load as the main generators to which they are connected.

As long as the house transformer bus and auxiliary generator bus are electrically independent, the conditions in the main and auxiliary generators will depend upon their loads and power-factors. Figure 4 is the full-load diagram for a large generator having 28 deg. voltage shift for full-load, 80 per cent power-factor lagging. If the auxiliary generator is carrying no load, its voltage will be 90 deg. behind the field as indicated by E_{aux} in Fig. 4. The voltage of the transformer bus will lag behind the generator field 118 deg. when the main generator is carrying full-load, 80 per cent power-factor lagging. Under these conditions, the voltage of the auxiliary generator bus will lead that of the house transformer bus by 28 deg. If the tie circuit breaker were closed, the terminal voltage of the auxiliary generator would be shifted back, forcing the small generator to take a load corresponding to the main generator load. The load taken by the auxiliary generator depends upon that of the main generator and will not be affected by the auxiliary load (except for a slight change due to impedance drop in the transformer).

In order to synchronize the two machines, the two busses should be as nearly as possible in phase. The main and auxiliary generators should both be carrying approximately the same per cent of full load. If the two bus-voltages are much out of phase when the tie circuit breaker is closed, the auxiliary bus voltage will be caused to shift suddenly. This may cause trouble with the auxiliary motor load, particularly if any synchronous load is carried. The

most certain way is to parallel when both machines are carrying no load.

Since it is not necessary to transfer power to and from the main bus in order to maintain a proper heat balance, as in the case of a house turbine unit supplying exhaust steam for feed water heating, in general it will not be desirable normally to operate a shaft-driven generator in parallel with the main system. One of the advantages of the shaft-driven generator is to provide a reliable source of power electrically separate from the main system. When parallel operation is required in order to transfer load or to meet emergency conditions, precautions as pointed out above should be taken to make sure that the voltages are the same in both magnitude and phase relation.

Parallel Operation With Turbine-Driven House Units

In some new additions to existing plants, shaft-connected auxiliary generators are being installed where the old installation used separate turbine-driven house units to supply power for the auxiliaries. In these cases, the question arises as to the effect of operating the new shaft generators in parallel with the house generator. Figure 5 shows an arrangement of this sort. Provision is made for paralleling the house generator and shaft generator through a bus-tie circuit breaker. The operating characteristics of this combination are different from those found in the parallel operation of two separate turbine-driven generators.

The shaft-driven generator and the main generator to which it is coupled constitute a synchronous tie between the main system and auxiliary system. The frequency of the auxiliary supply will, therefore, depend upon the system frequency which, in most cases, is maintained very nearly constant. The load taken by the turbine-driven house unit depends only upon the setting of its governor and upon its speed. Since the speed is determined by the main system frequency, which can be assumed to remain constant, the load taken by the turbine-driven unit for a given setting of its governor will remain constant regardless of changes in the load demanded by the auxiliary motors. Any difference between the power output of the turbine-driven house generator and power demanded by the auxiliaries will be supplied by the shaft generator.

For a given setting of the house-turbine governor and a constant load on the auxiliary bus, a slight change in system frequency will result in a change in load division between the shaft-driven and turbine-driven auxiliary generators. A decrease in frequency will increase the load taken by the turbine-driven unit and decrease that supplied by the shaft generator. An increase in system frequency will have the reverse effect. This combination is, in reality, the same as a system using a separate turbine-driven house unit with a synchronous tie with the main system by means of a synchronous motor-generator set.

In the ordinary system, the house turbine would be controlled in accordance with the exhaust steam requirements. In the case of operation with the shaft generator, however, the feed water would be heated by steam bled from the main turbine. The house unit would probably be continued in operation under the back pressure for which it was designed and the main unit would be bled to supply the additional steam required.

In general, it would be more satisfactory to operate the two busses independently. Load can be divided between the two units by switching motors from one bus to the other. The division of load between the two units would be unaltered by slight changes in system frequency. If it was found desirable to parallel the two busses, they would have to be synchronized in the ordinary manner before the tie circuit-breaker could be closed. The precautions which must be taken to insure satisfactory parallel operation of a shaft generator with the main system would, in this case, be unnecessary, as the phase position of the turbine-driven unit is independent of the main system.

Parallel Operation of Two Shaft Generators

In plants having more than one shaft driven auxiliary generator, each unit normally supplying its own auxiliaries electrically independent of the others, it may be desirable

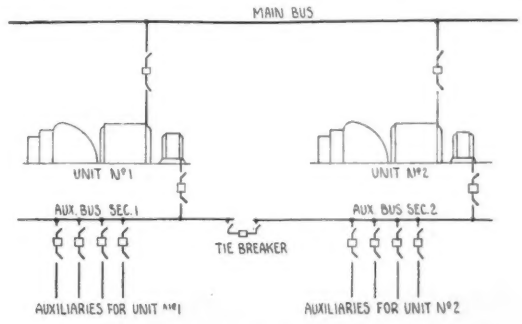


FIG. 6. PARALLEL OPERATION OF TWO AUXILIARY GENERATORS

in emergency to supply the auxiliaries of one main unit from the auxiliary generator of another. Figure 6 shows a bus arrangement which permits this to be done. In most cases, the two auxiliary bus sections would be operated separately; however, under special or emergency conditions, parallel operation might be considered.

If two shaft-driven generators are to be paralleled, the same precautions must be taken as were pointed out above in the discussion of parallel operation with the main system. If the rotors and stators of both auxiliary generators are in the same position relative to those of the main generators, the voltages of the two auxiliary bus sections will be in phase when both main generators are connected to the main bus and are carrying approximately the same per cent of full load. There is a possible danger of a generator field becoming reversed, in which case the voltages would be 180 deg. out of phase. The most certain way to parallel would be when all machines are unloaded but this would seldom be possible.

When operated in parallel, the division of load between the two auxiliary generators depends upon a number of factors. If one of the main units is carrying a greater load than the other, its shaft generator will be forced to take more than its share of the auxiliary load. If the output of this generator should be greater than the power demand of the auxiliary motors, it will drive the other auxiliary generator as a motor.

Unless the two main units were of identical design, they would probably have slightly different displacement angles between their no-load and full-load voltages. This

would cause their shaft generators to divide the load unequally. If both auxiliary generators had the same displacement angle for full load, the one connected to the main generator having the greater shift would take a greater per cent of rating than the other, even though the main generators were each carrying the same per cent of rating.

When two shaft generators are paralleled, any condition tending to cause surging between the main generators would cause a similar surging of load between the auxiliary generators. Should one of the main units be shut down or overspeeded, it would be necessary to separate the two auxiliary units, since the large generator would pull its shaft generator out of step and cause considerable disturbance on the auxiliary bus. Because of these conditions, it is not likely that shaft generators will be normally operated in parallel. If proper precautions are taken, however, provision may be made to tie them together temporarily in order to transfer load without an interruption, or for other reasons.

General Conclusions

As indicated in the foregoing discussion, a number of rather unusual conditions arise when an attempt is made to operate shaft-driven auxiliary generators in parallel with other sources of auxiliary power. The three cases considered cover practically all that will be encountered, although combinations of the three might be met. Because of the possibilities of overloading the direct-connected house generator when paralleled with other sources of auxiliary power, and on account of the danger of transmitting system disturbances to the auxiliary power system, it is recommended that such parallel operation be only temporary. If the proper precautions are taken, they may be paralleled for the time necessary to transfer the auxiliary load without danger of injury to the apparatus.—The Electric Journal.

Construction of Power Plant Walls

Steel Framework With Brick Filled Wall and Steel Window Sash Makes Excellent Construction

CHOICE OF THE type and materials for building walls above the foundation will vary within wide limits depending upon the permanency of the installation and upon its location. It is rarely, if ever, economy to cheapen building construction; for instance, a central station would not attract the public if the buildings were designed only from the viewpoint of utility, nor would an industrial manager be wise to deviate from the general style of architecture of other buildings of his factory group. It generally pays to study more than the bare utility of the power plant building.

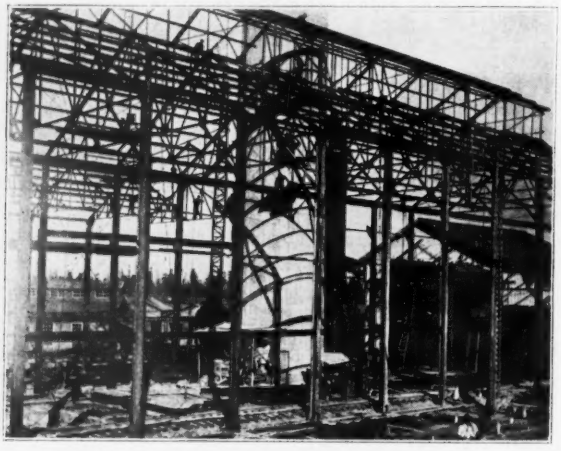


FIG. 1. STEEL FRAMING FOR A BOILER HOUSE

Wall construction may be of any of the following types: plain brick with pilasters; steel frame with filled wall; steel frame with metal sheeting; or, wooden frame with either metal sheeting or wood sheathing. The last named construction need not be given consideration except for temporary structures. It cannot be considered as a permanent structure and it is highly inflammable. The plain brick wall is often found in the smaller plants where the walls are of moderate height and where the engine room is not provided with an electric traveling crane. Pilasters should be built wherever roof trusses rest upon the wall.

Brick laid with the long dimension parallel with the wall are called stretchers, while those laid across the wall are called headers. Generally every fourth or sixth rows are laid as headers. The safe working stress for brickwork, including walls and piers, with heights less than six times the least dimension, is 8 T. per sq. ft. if laid in lime mortar (1 lime to 6 sand). If laid in a 1 to 3 cement mortar a working stress of 20 T. may be allowed.

Brick walls, the equivalent of two stories in height need be but 12 in. thick. Walls the equivalent of four stories in height may be 20 in. thick for the first floor, 16 in. for the height of the second and third and 12 in. thick for the equivalent of the fourth floor.

Steel Construction Is Most Common

The most common type of wall construction is that of a steel frame with filled walls, the steel taking all direct loads such as the weight of the roof, snow, sleet and crane loads. The steel also furnishes the necessary rigidity of the structure to withstand the stresses due to wind pressure. In many cases the steel work also carries the full weight of the windows and wall material. It is evident that this would have to be the case where large window space is required. A heavy girt or structural number would be placed above each window to carry the load of the wall above to the steel columns.

To conserve space the fill wall is usually built with its outside face flush with the outside face of the steel columns, then at the columns the brickwork is carried out to form a pilaster effect and so protect the steel from the weather. The selection of brick for either the solid wall or the brick fill wall depends upon that used in the surrounding buildings and upon the amount of money allowed for this purpose. A face brick backed up with run of kiln brick is often used. The outside joints being struck or undercut and the interior given several coats of a suitable brick paint.

To finish off the appearance of engine rooms a glazed brick is often laid up from the floor line to a height of 6 or 7 ft. The brick work above that may be either glazed or painted, the latter, of course, offering the more economical job. Sheet metal walls are not to be recommended because of heat loss in winter and heat penetration in summer. They are also subject to sweating under rapid changes of air conditions.

Other materials which may be used for filled wall construction are tile and metal lathe and plaster. The latter, however, is seldom used and the former is found most often in walls which are later to be taken out when additions are made to the plant. Composition board is often secured on the inside surface of a temporary wall. This may be painted so that it will have the general appearance of the other permanent walls.

Reinforced concrete has been used with success for the entire column and wall structure of power plants. This

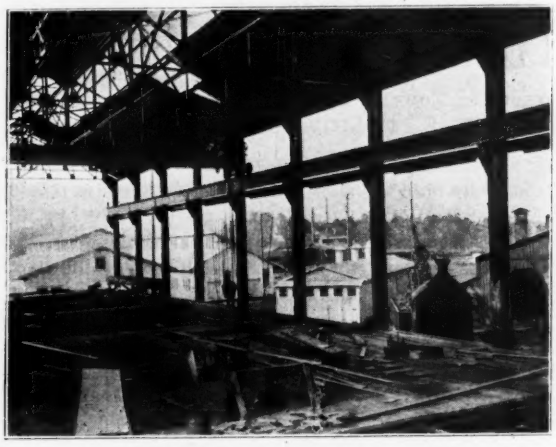


FIG. 2. STEEL FRAME AND CRANE RUNWAY FOR A TURBINE ROOM

construction is permanent and the maintenance is low; however, the inside columns take up more floor space than the corresponding steel column. This construction has not come into general use.

Partition wall construction between the engine and boiler rooms is usually the same as that used for the outside wall. An innovation in the construction of this wall has recently come into use. This is the use of steel framework and a continuous line of high steel-window sash. In this way some of the daylight from the engine room reaches the rear of the boilers. This is an excellent idea and one which could well be adopted in a great many installations.

Too often the question of day light is not given sufficient consideration. Ample daylight results in a more pleasant working condition for the workman, it is a material aid in the reduction of accidents and it eliminates in a great measure the station operating expense for lighting.

It is now common practice to partition off the space above the coal bunkers from the rest of the boiler house. This can be done either with tile or with steel lathe, plastered. Reinforced concrete has also been used for this purpose.

Of great importance in the operation of a power plant is the question of runways and stairways. Stairways are always more safe than ladders and should be used wherever possible. The treads may be made of specially formed open work or of steel channels turned with the legs up and the spaces between filled with concrete. The concrete tread surface should be rough or have imbedded in it some coarse and hard material such as carborundum chips.

Feed Water Regulation Effects Saving

REPORTS by the A. C. Nielsen Co. from two plants using feed water regulators show savings which will be of interest to power plant managers. At the Montville, Conn. plant of the Eastern Connecticut Power Co., Babcock & Wilcox boilers are used, carrying a pressure of 275 lb. and superheat of 180 deg. There are two boilers of 980 hp. each and four of 880 hp. each, the two larger being installed after the others had been in use for 3 yr. and equipped with regulators of the same make. Boilers are equipped with mechanical stokers, have forced and induced draft, and run at 250 to 300 per cent rating. Feed water is supplied through Cochrane open heaters at temperatures of 210 and 280 deg.

Data of operation of the plant are given by J. E. Casey, operating engineer, as follows: Turbo-generating sets carry the load which is largely industrial with a smaller lighting load. Demand comes on suddenly in the morning, then drops off. It picks up suddenly at noon and drops off towards evening with lighting load in winter coming on gradually and overlapping the industrial load. Fluctuations are more or less rapid during the day. One stoker man and one assistant operate the plant, the stoker attendant having charge of maintaining the water level, which, however, involves practically no work. No repairs have been required, not even repacking, in 3 yr. and the regulators have never failed to operate.

Savings and Advantages

During the year of hand operation of the feed, a considerable amount of the attendant's time was taken up in the regulation of the feed, water level was varying and water was fed into the boilers irregularly, tending to give uneven distribution of load between the boilers. With automatic control, pressure remains constant at 275 lb., feed water temperature at 210 deg., with practically no fluctuation, except when there is insufficient exhaust steam in the heater. Input of feed water is steady, varying only with fluctuations of the load and no forcing of the boilers is required because of feeding in large amounts of cool water suddenly. Average feed water temperature has increased about 20 deg. which on the usual basis of estimate, means a saving of 2 per cent in fuel. Other savings due to more even conditions of operation are estimated at 3 per cent, the total of 5 per cent amounting to $10,402 a year on the basis of 95 T. of coal burned a day at $6 a ton. As against this, the yearly cost of operation of each regulator for depreciation, interest, maintenance and repairs is estimated at $39.31 or 13 cents a day, giving $235.86 a year for the six regulators.

Data from another plant, Station B of the Philadelphia (Pa.) Gas Works, are also of interest. This station installed its first regulator 15 yr. ago and that regulator is

still giving continuous service with no renewal of parts except the piston and rings in the valve. Fourteen Babcock & Wilcox boilers from 265 to 347 hp. and eight waste-heat, vertical tubular boilers make up the equipment of the plant. Steam is used for making gas and for driving turbines, engines generating machinery and other machines about the plant. The loads fluctuate rapidly, hot gases passing through the waste-heat boilers intermittently at intervals of about 4 min., which makes control of the feed water difficult and important. Oil is used as fuel, steam being carried at 100 lb. in summer and 125 lb. in winter.

Feed water is drawn through a Cochrane preliminary heater and then through one of three secondary heaters before going to the boilers, the heating with exhaust steam raising the temperature to 210 to 212 deg. In the waste-heat boilers, the intermittent heating causes the water to tend to rise and fall rapidly so that it takes expert attention to regulate the level but the regulators have done it satisfactorily over a period of years. Feed water temperature is maintained practically constant, although the flow varies widely in proportion to the load. Also the pressure stays quite constant under operation with the regulators, although it varied considerably with hand regulation. It is estimated that the steadying of conditions results in an efficiency increase equal to saving 1½ per cent of the fuel. As the plant burns 28,000 gal. of oil a day at 3½ cents a gallon, this is a saving of $5365.50 a year in the fuel bill and the saving in labor cost over hand regulation is estimated at five men, single shift, or $6250 a year.

Constant service with the minimum of attention and a pronounced saving in the cost of operation is the verdict given by the owners of the plant. Figures and results of these performances are vouched for by the A. C. Nielsen Co., which made the surveys of the plants for the Northern Equipment Co., manufacturers of the Copes System of feed water regulation which is used.

Centrifugal Fans and Their Characteristics

PART III. APPLICATION OF FAN PRINCIPLES TOWARD THE SELECTION OF FANS FOR VARIOUS PURPOSES. BY R. T. LIVINGSTON*

IN ORDER to illustrate the laws explained in the previous articles in this series† and to show the method of selecting a fan to meet specified conditions, we will do

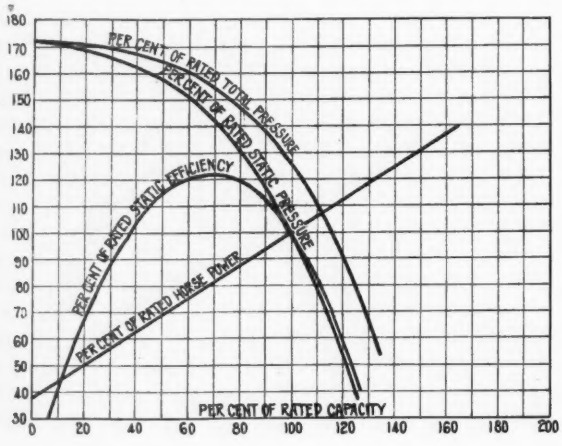


FIG. 1. TYPICAL CHARACTERISTIC CURVES OF STEEL BLADE-FAN

an illustrative problem. This problem will first be solved for standard conditions of temperature and later the effect of changes in temperature will be shown.

Let us assume that a fan is required to handle 25,000 cu. ft. of air against a static pressure of 2.75 in. of water. We will further assume that from a consideration of the shape of the characteristic curves it has been decided that a fan of the "steel plate type" will be satisfactory. Figure 1 shows a typical characteristic curve for this type of fan and Fig. 2 gives the capacity tables for this same type. From this table we see that either a No. 90 or 100 fan will very nearly meet the conditions, the former at some point above "rated capacity" and the latter at some point below "rated capacity." At 2.5 in. static pressure No. 90 fan will deliver 23.300 cu. ft. per min. at 505 r.p.m. and at 23.30 hp. and No. 100 will, at the same static pressure deliver 28,800 c.f.m. at 454 r.p.m. and at 28.70 hp. The problem, therefore, is to decide which of these two fans will be the more satisfactory and to determine the particular points of operation of each, including the speed.

Applying the laws, we can see that at a static pressure of 2.75 in. the speeds and capacities will be (remembering that speed and capacity will both vary as the square root of the pressure ratio):

$$\sqrt{\frac{2.75}{2.50}} = \sqrt{1.105} \doteq 1.05$$

Fan No. 90 r.p.m. = 530 c.f.m. = 24,500
Fan No. 100 r.p.m. = 476 c.f.m. = 30,200

Obviously neither of these fans can meet the specified conditions exactly at the rated efficiency point and so it will be necessary to operate at a point either above or below according to the fan selected.

If we wished only an approximate solution, we have gone sufficiently far; however, it will be better to continue through and obtain a complete and more accurate solution of the problem. In order to force the fan to operate at some other point on the curve than the rated point, it will be necessary either to increase or decrease the resistance against which it is operating which will take it below or above rated capacity as the case may be. Therefore as the best method of getting at the point of operation is the total pressure we will first figure the velocity head and then by finding the ratio between total and static pressures we can determine the exact point of operation from the curve in Fig. 1.

The discharge or outlet areas are 7.1 sq. ft. and 8.75 sq. ft. respectively. The velocity heads ($V^2/2g$) will then be 53 ft. and 35 ft. respectively, which, when reduced to inches of water, becomes 0.76 in. and 0.5 in. Hence the total pressures will be 3.51 in. = (2.75 in. + 0.76 in.) for the No. 90 fan and 3.25 in. (= 2.75 in. + 0.5 in.) for the No. 100 fan and the ratio of the total pressure to the static pressure will be 127.5 per cent and 118. + per cent

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†November 1 and November 15 issues.

respectively. Now we must find some point where the total pressure is 127.5 per cent of the static pressure for No. 90 fan and some place where it is 118. + per cent of No. 100 fan. By inspection of the characteristic curve these are seen to be at capacities of 101.5 per cent and 91 per cent respectively. In the first case the total pressure is 123.75 per cent of the rated static and the static is 97.25 per cent of rated, in the second the total pressure is seen to be 136.5 per cent and the static pressure 118.5 of the rated static pressure, by dividing each total pressure by the corresponding static pressure it is seen that in the first case it is 127.5 per cent and in the second case 118.2 per cent which are the ratios desired. In the first case the hp. is 101 per cent and the second 94 per cent of the "rated horsepower." This then settles the proper "points of operation" for each fan.

It now remains to determine the correct speed and horsepower, for the required point of operation. Taking fan No. 90 up first and computing the "rated" quantities from these values found we shall have;

$$\text{rated quantity} = 25{,}000/101.5 = 24.650$$
$$\text{rated static pr.} = 2.75 \;/\; 97.25 = 2.83 \text{ in.}$$
$$\text{horsepower} = 101 \text{ per cent of rated.}$$

Now from the table in Fig. 2 we see that at 2½ in. static pressure fan No. 90 will give 23.300 c.f.m. at 505 r.p.m. and take 23.3 hp. Now remembering that the r.p.m. vary directly as the quantity and as the square root of the pressure we will compute the quantity ratio (which is the same as the speed ratio).

$$\text{quan. ratio} = 24{,}650/23{,}300 = 1.059$$
$$\text{R.p.m.} = 1.059 \times 505 = 535$$

as a check compute pressure ratio; $= 2.83/2.5 = 1.13$

$$\text{square root of } 1.13 = 1.06$$

As horsepower varies as the cube of the speed we will multiply the given hp. by the cube of the ratio;

$$1.2 \times 23.3 = 28.0 \text{ hp.}$$

Now we know that the actual horsepower used is 101 per cent of the rated therefore true horsepower will equal

$$28 \times 101 \text{ per cent} = 28.25 \text{ hp.}$$

In a similar manner we can find for fan No. 100 that it must run at 435 r.p.m. and that it will require 24.5 hp. to deliver 25,000 c.f.m. against a static pressure of 2.75 in. (It may be seen that the "rated" quantities are; Q = 27,500, static pressure = 2.28 in., and hp. = 94 per cent of the rated.)

It is now a question of balancing the lower first cost of the No. 90 fan against the lower power consumption and lower speed of the No. 100 fan and that is a case where various local conditions of operation will dictate choice and not theoretical consideration.

If the r.p.m. as well as the quantity, pressure and type of fan is fixed the problem becomes very difficult of solution and it may be that the conditions desired can only be reached at a great sacrifice of efficiency. This condition is obvious when one considers the laws of fan performance and the peculiar shape of the characteristic curve. For each speed there is a definite quantity and pressure for rated conditions and if we wish an increased quantity above that point we must accept at the same time a decrease of pressure, provided we keep the speed constant and vice versa if we wish an increased pressure we shall get it only with a decreased quantity.

So far we have dealt only with air at standard conditions (70 deg. and Bar, 29.92 in.) and it is for these conditions that the fan tables are written. Let us now assume that the fan is required to handle this same quantity of hot gases at a temperature of 650 deg. F. We will assume that the density of the gas to be handled is the same as air. This will be sufficiently accurate for all such problems as induced draft as the temperature affects the answer to a much greater degree than the density. From the laws given in the previous article we know that if speed and quantity are kept constant the speed, horsepower and pressure will vary (approx.) inversely as the absolute temperature and incidentally directly with the density. Therefore the first thing to do is to calculate the temperature ratio.

$$460 + 650 = 1110 \text{ and } 460 + 70 = 530$$

Then $530/1110 = 0.482 = K =$ temperature ratio.

The desired pressure is 2.75 in. then the corresponding "standard conditions" pressure will be $2.75/0.482 = 5.72$ in. static pressure. In a similar manner the standard condition horsepower × 0.482 will equal the "given condition" horsepower. This may be translated to indicate that a fan which will deliver 25,000 c.f.m. against 5.72 in. static pressure at 70 deg. F. will also deliver 25,000 c.f.m. at 650 deg. F. and against 2.75 in. static pressure, therefore we must select a fan for this condition. Unfortunately the tables do not extend this far, hence we must extend them by the same laws of fan performance, or,

CAPACITY, HORSEPOWER AND SPEED TABLES FOR STEEL PLATE FAN

70° F. 29.92" Barometer

Size	Diameter of Blast Wheel Inches	Area of Outlet Square Ft.	½" Static Pressure = 0.208 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	¾" Static Pressure = 0.433 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	1" Static Pressure = 0.577 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	1½" Static Pressure = 0.865 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.
30	19¼	0.77	675	1,100	0.33	830	1,420	0.42	958	1,640	0.56	1174	2,010	1.16
35	22½	1.06	580	1,370	0.41	713	1,695	0.56	823	1,220	0.67	1008	2,720	1.61
40	25¾	1.36	508	2,060	0.61	625	2,550	0.73	722	2,950	1.15	886	3,580	2.13
45	29⅛	1.72	451	3,000	0.83	553	3,105	0.98	638	3,660	1.47	783	4,510	2.70
50	32½	2.10	407	3,230	0.84	498	3,960	1.18	574	4,552	1.52	705	5,580	3.30
55	35¾	2.61	369	3,890	0.77	452	4,795	1.43	523	5,560	2.19	640	6,760	4.05
60	39⅛	3.13	339	4,630	0.89	415	5,675	1.70	479	6,550	2.61	587	8,050	4.80
70	45	4.26	290	6,330	1.25	355	7,730	2.31	410	8,950	3.55	503	10,920	6.52
80	51¾	5.54	254	8,230	1.64	310	10,050	3.02	359	11,650	4.62	440	14,170	8.50
90	57½	7.10	226	10,410	2.08	276	12,730	3.82	319	14,730	5.88	391	18,060	10.80
100	64⅜	8.73	203	12,880	2.56	248	15,750	4.71	287	18,200	7.25	352	22,300	13.32
110	70⅝	10.57	185	15,550	3.10	226	19,100	5.71	261	22,000	8.78	320	26,950	16.12
120	77⅛	12.60	169	18,520	3.69	207	22,700	6.78	239	26,200	10.44	293	32,080	19.18
130	83½	14.85	156	21,600	4.31	192	26,450	7.93	221	30,550	12.20	271	37,410	22.40
140	90	17.30	145	25,300	5.02	177	30,850	9.24	205	35,650	14.26	251	43,700	26.16
150	96¼	19.70	133	28,950	5.76	165	35,400	10.62	191	40,900	16.20	234	50,150	29.95
160	102	22.40	127	32,900	6.57	154	40,250	12.10	179	46,450	18.60	219	56,900	34.17
170	109¼	25.40	120	37,120	7.42	146	45,300	13.65	169	52,550	21.00	207	64,400	38.60
						138								
180	115⅝	28.50	112	41,700	8.31		51,100	15.35	159	59,000	23.50	195	73,350	43.15
190	122⅛	31.70	107	46,300	9.26	131	56,700	17.05	151	65,500	26.20	185	80,250	48.10
200	128½	35.20	101	51,500	10.25	125	63,100	18.85	144	72,850	29.00	175	88,200	53.30

Size	Diameter of Blast Wheel Inches	Area of Outlet Square Ft.	2" Static Pressure = 1.154 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	2½" Static Pressure = 1.443 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	3" Static Pressure = 1.734 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.	3½" Static Pressure = 2.079 Ounces R.P.M.	Volume Cubic Ft. per Min.	H.P.
30	19¼	0.77	1355	2,320	1.84	1515	2,595	2.57	1660	2,840	3.38	1792	3,070	4.29
35	22½	1.06	1160	3,140	2.52	1296	3,510	3.48	1420	3,845	4.63	1534	4,155	5.85
40	25¾	1.36	1015	4,155	3.28	1135	4,630	4.58	1245	5,085	6.03	1345	5,490	7.66
45	29⅛	1.72	904	5,210	4.15	1010	5,825	5.81	1106	6,372	7.63	1195	6,880	9.65
50	32½	2.10	814	6,440	5.10	910	7,200	7.20	996	7,880	9.45	1076	8,510	11.91
55	35¾	2.61	739	7,780	6.16	826	8,700	8.68	904	9,530	11.38	976	10,290	14.34
60	39⅛	3.13	678	9,260	7.38	758	10,370	10.31	830	11,340	13.55	896	12,250	17.10
70	45	4.26	580	12,630	10.03	648	14,120	14.03	710	15,460	18.44	767	16,700	23.25
80	51¾	5.54	508	16,490	13.12	568	18,400	18.40	621	20,150	24.10	672	21,800	30.40
90	57½	7.10	451	20,850	16.60	505	23,300	23.20	552	25,500	30.55	597	27,550	38.50
100	64⅜	8.73	406	25,750	20.45	454	28,800	28.70	497	31,550	37.70	537	34,050	47.50
110	70⅝	10.57	369	31,100	24.80	413	34,800	34.70	452	38,100	45.60	488	41,100	57.38
120	77⅛	13.00	339	37,050	29.50	378	41,460	41.30	414	45,400	54.25	447	49,000	68.40
130	83½	14.85	312	43,350	34.50	349	48,500	48.35	382	53,200	63.60	413	57,300	80.05
140	90	17.30	290	50,400	40.15	324	56,400	56.15	355	61,750	73.80	384	66,700	93.00
150	96¼	19.70	270	57,900	46.10	302	64,750	64.50	331	70,900	84.70	358	76,600	106.80
160	102	22.40	253	65,700	52.60	284	73,500	73.50	310	80,600	96.40	335	86,970	121.90
170	109¼	25.40	239	74,300	59.40	267	83,200	83.00	293	91,000	109.00	316	98,400	137.50
180	115⅝	28.50	226	83,500	66.80	251	93,400	93.00	277	102,300	122.70	298	110,600	154.00
190	122⅛	31.70	214	92,850	74.20	239	103,700	103.60	262	113,300	136.00	282	122,500	171.50
200	128½	35.20	204	103,000	82.60	226	115,100	114.70	250	126,100	150.80	269	136,300	190.00

Total Pressure is 126% of the Rated Static Pressure.

which is probably easier, reduce this condition to an equivalent one at 3½ in. static pressure so that we can select.

Pressure ratio is $5.72/3.5 = 1.635$. Now speed ratio = quantity ratio and equals the square root of pressure ratio. Hence speed ratio = $\sqrt{1.635} = 1.28$.

Then $25{,}000/1.28 = 19{,}500$ = equivalent quantity at 3½ in. static pressure. From a glance we can see that this lies between fan No. 70 and fan No. 80. From this point on we can proceed exactly as we did in the previous part and select the best fan for this condition which will be the best fan for the original desired condition.

Hints on Refrigerating Plant Operation*

USE OF OPERATING RECORDS AND PROCEDURE TO FOLLOW IN CARRYING OUT MAINTENANCE WORK. BY JOHN W. NEFF

IN OPERATING a refrigerating plant the engineer should keep a plant log or daily operating report, on which are recorded time, pressures, temperatures and r.p.m. of compressors, meter readings, chemical tests of treated water, blocks of ice pulled on each watch, and weight of blocks, number of tank and row, pay roll and other such items. As a rule, the log sheet form has to be made up for the individual plant, or plants operated by one company.

An original or a copy of each report should be kept. This will furnish a record with which to make comparisons by the day, week or month. Always strive to do a little better each succeeding week or month, as the case may be. In case the kw-hr. per ton go up or tonnage drops off, by making a careful study of pressures and temperatures of the log sheets past and present, he can usually account for the trouble. Chemical tests of the treated water should be made each time the water softener is recharged, and the results entered on the daily log. The number of tank and number of row of ice pulled on each watch should also be entered on the daily log, with the number of cracked, white or poor quality blocks; then, by referring back to the chemical tests of the water when the rows in question were filled in, he can proportion the chemicals, so as to eliminate the trouble partially, if not entirely.

It is also an aid to efficient operation to have a complete detailed record of all the equipment in the plant. This should include shop number, size and r.p.m. of compressors, and type of valves (direct connected or belt driven); if belt driven, r.p.m. of motor, diameter of pulleys, width and length of belt, and the same of all pumps, blowers, air compressors, hoists, cranes, elevators and motors. Other items are size of storage rooms, kind and thickness of insulation, square feet of direct expansion or brine coils in storage, and the disposition of the coils, whether placed on ceiling or wall, if aprons or bunkers are used to aid air circulation, square feet of evaporating surface in ice freezing tanks, whether coils or shell-and-tube cooler, velocity of brine in feet per second, length and width and depth of tanks, location of bulkheads and partitions, size, speed and location of brine agitators, size and number of ice cans, type of condensers, square feet of cooling surface, gallons of water per minute put over or through condensers, size and length of suction, discharge, liquid and equalizer lines, size and location of accumulator or liquid trap and oil separator, size and location of liquid receiver with relation to condenser.

As a rule, most of the information is furnished by the consulting engineer, but in case it has been mislaid or destroyed, a good time to get it is when the plant is shut down for overhauling. With this data, in connection with the daily log sheet, the engineer can figure out whether or not he has a properly balanced plant, find where he is short and where he is long. This will enable him to put a proposition before his employer for new equipment, or changes in the present layout, in an intelligent manner, and with confidence in his recommendations. He should keep a record of the supplies used each month, such as coal, oil, grease, waste, salt, calcium, ammonia, lime, alum, etc. This can be reduced to pounds or gallons (as the case may be) per ton of ice made. This makes an interesting and valuable record to refer to from month to month or year to year.

A record of parts renewed, such as repairs to hoists, can filling tanks, contact points on controllers, compensators, oil switches and fuses, should also be kept. This will give a fair idea of what repair parts and how many of each to carry in stock. A few dollars invested in repair parts is cheap insurance against the loss of daily capacity production. He should keep a book in which he makes notes of repairs or changes (as they occur to him during the season's run), to be made when the plant is shut down for overhauling. By so doing, nothing will be overlooked. When the plant is shut down for general inspection and overhauling, it should be gone about in a systematic manner, by referring to the notes he has made during the operating season of repairs, changes, or installation of additional equipment. He can plan his work ahead so as to work to the best advantage.

Each part of the plant and equipment should be put in perfect working order, so that the danger of a failure during the coming season is reduced to a minimum, remembering that if you take care of the little things, you are reducing the number of big ones to a minimum.

Besides the regular small tools kept in the plant, there should be a chain hoist, screw jacks, wood blocking, ropes, chains, sledge hammers and crow bars. This will speed up the work and at the same time make it easier for the help.

When local conditions do not make it advisable to do otherwise, would suggest the work be taken up in the following order: Compressors, condensers, ammonia, piping, valves and pipe covering, direct expansion and brine piping, ice freezing tanks and equipment, raw water equipment, water cooling equipment and electrical equipment.

COMPRESSOR

Since the compressor is probably the most important part of the compression system, it is quite obvious that each part subjected to wear should be examined and put in first class shape. Suction and discharge valves should be taken apart, examined closely, and ground to a perfect seat; tension on spring should be adjusted so as to get quiet action, and no wiredrawing effect. By a little experimenting the proper tension can be found; then, by making two dead weights, one for suction and one for discharge valves, for the respective compressor, it is an easy matter to regrind and adjust the valves, piston rod, piston and packing.

Some engineers recommend heat treating the valves every two years to eliminate the danger of crystallization. If valve cages do not fit perfectly in the cylinder head, they should be ground to a perfect fit.

Packing should be removed; if metallic, care should be taken not to damage the rings, or get them interchanged.

*Presented at the 15th convention of the National Association of Practical Refrigerating Engineers at New Orleans, Nov. 11 to 14.

Remove the piston, examine the cylinder walls; if they have a high metallic polish and there are no grooves in them there is no need for the cylinder to be rebored; if shoulders have formed at the ends they should be ground or scraped down even with the cylinder surface. If rings are quite loose in the grooves, they should be renewed; if not, remove from the piston (being sure not to get them interchanged). Fit them into the cylinder at the point of the largest diameter. If they make good contact all around, have plenty of lap at the joint and are not less than ¼ in. thick at the point of smallest thickness, they need not be renewed.

Should the piston rod be scored or badly worn it should be trued up in a lathe and a large size packing used. It may be necessary to bush the stuffing box and gland, depending upon the amount turned off from rod bearings. All should be examined. Make sure that there is plenty of room for adjustment of wear for the coming season. See that all oil grooves are open and amply deep.

When piston is out it might be well to line up main shaft with center line of cylinder. When piston is replaced adjust crosshead so that its center is in line with center line of cylinder. Examine disc and crankpin to see if there are any signs of them being loose. If main stop and bypass valves have soft seats, be sure to examine them; if badly worn have them renewed. Use new gaskets in all joints. If fibrous packing is used on the piston rod it should be renewed.

If automatic oiling systems is used on the compressor be sure to clean the entire system thoroughly.

After all parts of the compressor have been thoroughly overhauled and examined the compressor should be carefully reassembled. When the compressor is put in operation the functioning of the valves and piston rings may be determined by taking indicator cards. On these indicator cards the usual adiabatic and isothermal compression curves are plotted for comparison.

Condensers

Should there be any leaks, pump out and repair them and renew badly corroded bolts and pipes. Clean the pipe of all scale, either by hand or mechanical means. Test with 250 lb. ammonia pressure. Paint all the pipes where the surface is not constantly flooded with water; also return bends, and 4 to 6 in. of the pipes on each end with red lead and boiled oil or any good rust-resisting paint. For the center of coils, paint with oil taken from separator or filter, as a coat of paint would reduce the transfer of heat. If double pipe or tubular condensers, scrape the tubes. If ammonia piping system, pump out the line, and in case there are any leaks repair them. See that hangers are in good condition and lines are well braced and anchored; to avoid vibration, repair all valves which you know have been leaking. Where valve stem packing has become hard it should be renewed. See that pipe covering is in good condition. If not, it should be repaired or renewed.

Should there be any leaks in the cooling coils, pump out and repair them. Be sure to examine the hangers which support the coils, to make sure there is no danger of them giving away when coils are heavily frosted. While in the storage, it might be well to examine the roof trusses where they join on to the brick wall, as quite a few failures have occurred at that point.

In case there are two tanks, pump brine into the other, or into the ice cans. Then pump out coils or cooler. Scrape the coils, examine the coils for pitting or corrosion, and the fittings for deterioration, due to action of brine; if in bad condition, they should be renewed. If they seem to be O. K., test with 100 lb. ammonia pressure. Make any needed repairs to the tank top, can supports and partitions, put agitators in first-class condition, clean all sediment out of tank, pump brine back into tank; the cans should be put in also, in order to cover all the coils with brine.

In case the brine is cooled with a shell-and-tube cooler the tubes should be scraped clean by means of a flue scraper or wire flue brush or both, as all scale must be removed from the inside of the tubes. After scraping, wash with city or tank pressure to remove any loose scale or sediment which may be left in the tubes. Examine pipe and fitting connections the same as in coil tank; test with 75 lb. ammonia pressure. A removable screen should be placed in front of the cooler to prevent small pieces of wood from entering the tubes. Inspect and put in first-class shape for the season's run, ice dumps, can filling tanks, cranes, hoists, conveyors and elevators.

Raw Water Equipment

Make any needed repairs to the air system, inspect the blowers or compressors and put in first-class shape. Put the mechanical equipment of the water softening system in first-class shape by cleaning and making any needed repairs. Remove the sand and gravel from filters, wash it clean or renew it, remove strainers and see that all openings are free of sand or other foreign matter and replace water cooling equipment and the filtering material, being sure to use the same amounts as taken out. Clean the sedimentation tank, examine the down-take to see that the chemically treated water is not short-circuiting due to openings in the down-take.

Make a thorough examination of the cooling tower (if of wood construction) for rotten or decaying timbers. In the spring of the year, after freezing weather has passed, the tower should again be inspected (in case it has been operated during freezing weather), to see that falling ice has not broken holes in one or more of the decks. If so, repair and renew any missing or loose wooden strips or louvers.

If spray system see that all nozzles have full opening and are not partially clogged with small pieces of wood or gravel. Pumps, if of the double suction centrifugal type, examine the wearing rings if worn, renew them; examine the impeller to see that small pieces of wood or gravel have not lodged in it.

Electrical Equipment

Inspect all compensators, controllers, oil switches and automatic starting devices. All contacts should be kept clean and if badly burned they should be renewed. The oil in oil switches should be renewed each season. Keep the interior of motors clean as well as the exterior by blowing out with low pressure air. Bearing linings should be inspected; if badly worn they should be renewed, as there is danger of the rotor rubbing on the stator.

The installation of a discharge gas water heater between compressor and oil separator will prevent most of the oil from entering the condensers, reduce the condenser

pressure, and heat all the water required for the dipping tank. The installation of a non-condensable gas separator, whereby the system can be purged of non-condensable gases without interrupting the continuous operation of the plant and with a minimum loss of ammonia.

One method for determining the presence of non-condensable gases in condensers consists of an accurate pressure gage and thermometer in the liquid line leading from the condenser to the receiver. When the temperature indicated by the thermometer is several degrees below the saturation temperature corresponding to the pressure the presence of non-condensable gases may be suspected.

An automatic pressure controlled condenser water valve, when set at a predetermined pressure, will automatically admit city water to the condenser, which will prevent running up a high demand charge. It will also keep the power consumption down on a hot, sultry day when the humidity is high, as it is cheaper to run a part of the warm condenser water to the sewer than to re-circulate it and operate with an excessively high condenser pressure.

In case the plant is short on can surface, the installation of a forecooler will shorten the freezing time and raise the suction pressure. This cooling, however, must not be done by passing the suction gas from the ice freezing tank through the forecooler coil, but should be connected and operated independently of the ice-freezing tank.

When brine for refrigerating ice storage is taken from ice-freezing tank the cooling should be done independently of the ice-freezing tank, either in a shell-and-tube or double pipe brine cooler.

In case the compressor is built to work on two back pressures the water forecooler and liquid precooler should be operated on the high pressure suction. This will reduce the power consumption per ton of ice.

An ammonia distiller will keep the ammonia charge pure and dry. It should be connected up so that oil can be drawn from the oil separator in the discharge line, ammonia and its impurities from the bottom of the liquid receiver and evaporating coils and brine cooler. The oil drawn from the distiller can be filtered and used over again by blending with new oil.

Thermometers and Gages

A duplex pressure recording gage connected to the suction and discharge lines will give a good check on how the plant is operated during a period of 24 hr., which should make a good record with which to check the daily log sheet.

The liquid receiver should be provided with a gage column or columns of approved type to indicate liquid level in receivers. A mark should be made on the column (by either painting or a metal shield) at least 3 in. above the liquid outlet pipe. If liquid level is not allowed to go below this point there is no danger of high pressure gas entering the evaporating coils. There should be a pressure gage and thermometer installed in the liquid line between condensers and liquid receiver for detecting the presence of non-condensable gases. When the temperature of the liquid ammonia leaving the condensers is below the saturated temperature corresponding to the pressure registered by the gage there are non-condensable gases in the system. (Both the gage and thermometer must be accurate instruments.)

The thermometer is as necessary to the refrigerating engineer as the compass is to the mariner. Use plenty of them. Thermometers of the separable socket type should be placed in the suction line leading from each freezing tank or evaporating system close to the tank or room, and in the discharge line close to the compressor. All thermometers and gages should be tested for accuracy at least once a year.

Suggestions on Plant Operation

Keep the suction pressure as high as possible and yet obtain the desired temperature difference between brine and ammonia. The brine should be circulated rapidly in order to increase the heat transfer between ice cans, brine and evaporating surfaces. A brine velocity of thirty feet is considered good practice. If possible to do so, keep brine level above finished block of ice in cans. This will reduce the freezing time from 15 to 20 per cent.

Keep the evaporator as nearly flooded with liquid ammonia as possible. This can be done by keeping the temperature of the suction gas as near as possible to the saturated temperature corresponding to the pressure; under ordinary conditions, the suction gas should not be superheated more than 4 to 7 deg.

Superheating the suction gas reduces the refrigerating capacity of the compressor and increases the power consumption. Under ordinary conditions do not try to keep the compressor cylinder cool by feeding liquid into the suction.

Keep all heat transmitting surfaces such as condensers, evaporating coils, in ice-freezing tanks and tubes in brine coolers clean both inside and out. A very cheap and efficient way to keep rust and scale from forming on the pipe surfaces and cans is to treat the brine with silicate of soda. It also has a tendency to clarify the brine.

Maintain an even distribution of water over the pipe surface of the condensers; adding a small amount of copper sulphate to the condenser water will prevent algae from forming on the coils. Keep the condenser pressure as low as possible.

Keep the density of the brine at a point where there is no danger of ice forming on the coils. Do not store ice in the freezing tank. Pull the ice with a small cup in the block on the basis of a 48-hr. freezing time; for every 400-lb. can of ice left in the tank four hours means a loss of 33 1/3 lb. of ice. See to it that the tank men pull the ice steadily. For example, if six rows are to be pulled in eight hours, start the rows 1 hr. and 20 min. apart.

Keep the system fully charged with ammonia at all times; running on an insufficient charge of ammonia is false economy. Keep the ammonia charge pure and dry by withdrawing oil and impurities at regular intervals and redistilling. Keep the system free of non-condensable gases. Do not permit ammonia leaks, no matter how small.

Brine should be tested for ammonia leaks at regular intervals, also the outlet water from individual stands of the closed flow type of condensers. On atmospheric type of condensers ammonia leaks will manifest themselves by an excessive deposit of lime salts.

In the spring and fall of the year the temperature of city water is from 15 to 20 deg. cooler than during July and August, while the condenser pressure is from 50 to 75 lb. lower. With this combination we do not need so much cylinder displacement per ton of refrigeration.

Sensible Heat in Boiler Refuse Causes Appreciable Loss

IN THE October 1 issue, the article, "Calculation of the Boiler Heat Balance" is most comprehensive and should prove of great help in power plant operation. The curves given in the article eliminate the necessity for carrying out the somewhat laborious computations, or for checking the results when the computations are carried out.

One item, however, is not accounted for individually in that article; that item is the heat loss due to sensible heat in boiler refuse. For some reason or other, this loss is usually slighted by being bunched with the "unaccounted-for" losses, instead of being given the individual consideration it deserves. As a rule, it is larger than the loss due to moisture in the air, loss due to moisture in the coal and CO loss.

In the operation of the average boiler, the refuse is about 25 per cent of the total amount of coal consumed. The coal is introduced into the furnace at the temperature of the surrounding air, say about 75 deg. F., and the refuse is removed from the furnace at a temperature slightly below that of the furnace. The specific heat of the compounds found in boiler refuse increases with the temperature and at the temperature at which the refuse is removed from the furnace, it is appreciable. Consequently, the loss due to that source is considerable and, what is most important, it is controllable. Therefore, it is justly entitled to an individual place in the boiler heat balance.

It has been pointed out by the writer that the heat loss

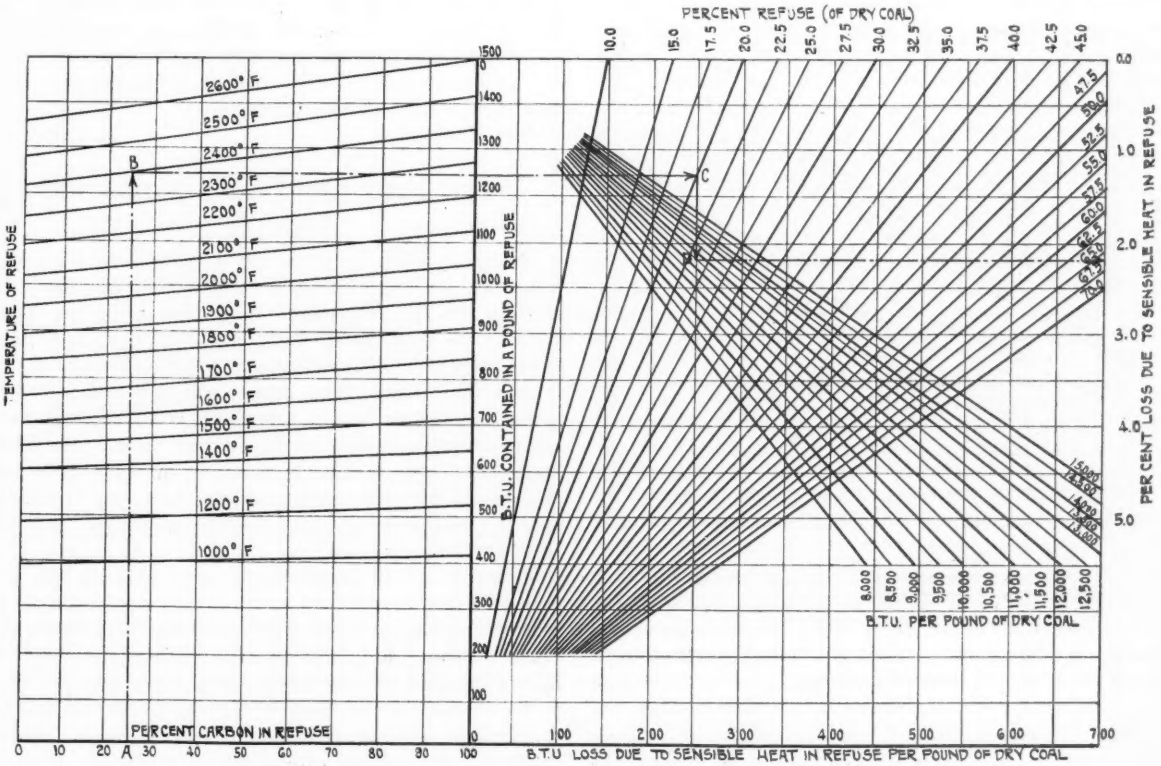

PERCENT REFUSE (OF DRY COAL)
TEMPERATURE OF REFUSE
B.T.U. CONTAINED IN A POUND OF REFUSE
PER CENT LOSS DUE TO SENSIBLE HEAT IN REFUSE
B.T.U. PER POUND OF DRY COAL
PERCENT CARBON IN REFUSE
B.T.U LOSS DUE TO SENSIBLE HEAT IN REFUSE PER POUND OF DRY COAL
A
B
C
D

FIG. 1. CHART OF LOSS DUE TO SENSIBLE HEAT IN BOILER REFUSE

1. From the point on the horizontal axis representing the per cent of combustible in the refuse, draw a vertical line until it intersects the line representing the temperature of the refuse leaving the furnace. This gives the B.t.u. contained in a pound of refuse.

2. Project this point horizontally to the line representing the per cent (of dry coal) of the refuse. The point of intersection gives the B.t.u. loss due to the sensible heat in refuse, per pound of dry coal fired.

3. Project this point vertically until it intersects the line representing the B.t.u. per pound of dry coal. The point of intersection gives the percentage B.t.u. per pound of dry coal lost due to sensible heat in refuse.

Example: B.t.u. per pound of dry coal, 11,500; per cent (of dry coal) refuse, 20.0; per cent combustible (carbon) in refuse, 25.0; temperature of refuse leaving furnace, 2400 deg. F.

Draw A-B. B represents B.t.u. contained in a pound of refuse = 1242 B.t.u.

Draw B-C. C represents B.t.u. loss per pound of dry coal = 250 B.t.u.

Draw C-D. D represents per cent (of dry coal) loss due to sensible heat in refuse = 2.2.

due to sensible heat in the boiler refuse varies directly as the per cent of ash in the coal, the per cent of combustible in the ash and the square of the temperature at which the refuse is removed from the furnace. As the per cent of combustible in the refuse and the temperature of it vary inversely as the time the coal is allowed to remain in the furnace, it follows that the loss of heat due to that cause is a function of the third power of the speed at which the coal is propelled through the furnace, which partly accounts for the decreased efficiency at forced ratings.

It is a comparatively simple matter to account for the heat loss due to sensible heat in boiler refuse. The per cent of refuse and the per cent of combustible in the refuse are usually determined in any boiler test and the only additional measurement required is that of the temperature at which the refuse is removed from the furnace.

Calculation of Typical Example

To illustrate the method of accounting for this loss, let us consider the example used in the article in the October 1 issue. The per cent of refuse is 21 and the per

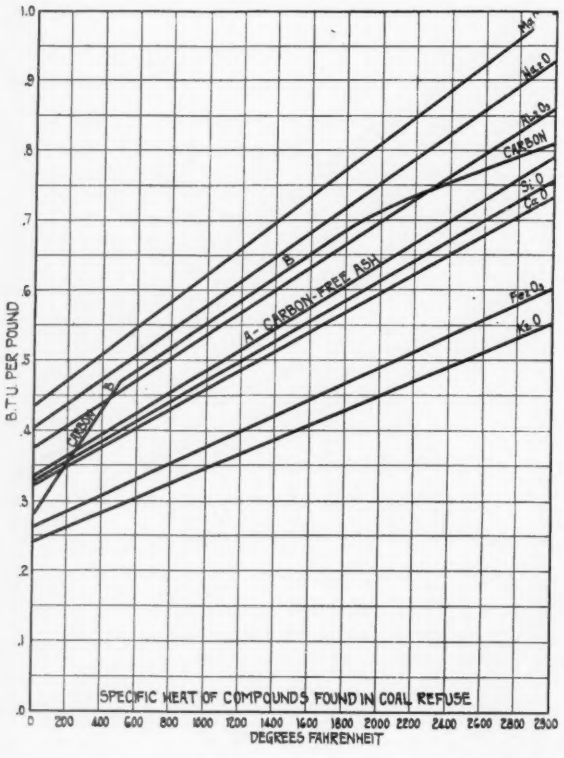


FIG. 2. CHART SHOWING SPECIFIC HEAT OF COMPOUNDS FOUND IN REFUSE

cent of combustible in the refuse (carbon) is 30. Let us assume that the temperature was measured by a pyrometer and found to be 2000 deg. F., at the instant the refuse was removed from the furnace. Obviously, the mineral portion of the refuse is equal to $0.21 \times 0.70 = 0.147$ lb. per pound of dry coal. (This figure should be 15.05, the per cent ash in dry coal; the discrepancy is due probably to the fact that the per cent of combustible in the refuse is 28.5, instead of 30, or the per cent of refuse might have been 21.5 instead of 21. However, the figure is close enough for all practical purposes.) The carbon portion of the refuse is equal to $0.21 \times 0.30 = 0.063$ lb. per pound of dry coal.

TABULATION OF SUCCESSIVE STEPS IN CALCULATING LOSS OF HEAT IN CARBON CONTENT OF REFUSE

Temperature Range Deg. F.	Specific Heat			Temperature Rise Deg. F.	B.t.u. Loss
	Initial	Final	Average		
75 to 500	0.28	0.47	0.375	425.	0.063 x 0.375 x 425 =10.1
500 to 1800	0.47	0.685	0.5775	1300.	0.063 x 0.5775 x 1300 =47.3
1800 to 2000	0.685	0.715	0.70	200.	0.063 x 0.70 x 200 = 8.83
Heat carried away by the incandescent carbon in the refuse					=66.23

From Curve A, Fig. 2, the specific heat of the mineral portion of the refuse (ash) is found to be 0.34 at a temperature of 75 deg. and 0.64 at a temperature of 2000 deg. The average temperature over the range is therefore $0.34 + 0.64 \div 2 = 0.490$. The temperature rise is $2000 - 75 = 1925$ deg. The loss of heat in this portion of the refuse is equal to $0.147 \times 0.490 \times 1925 = 138.00$ B.t.u., per lb. of dry coal. Since Curve B, Fig. 2, showing the specific heat of carbon, is a broken line, it becomes necessary to determine the loss in that portion of the refuse in several steps, as shown in the accompanying table.

The total heat loss due to the sensible heat in boiler refuse is $138 + 66.23 = 204.23$, say 204.0 B.t.u. The per cent loss is $(205 \times 100) \div 12{,}100 = 1.69$.

For all practical purposes, the accuracy yielded by charts is sufficient in making a boiler heat balance. The chart of "Loss Due to Sensible Heat in the Boiler Refuse" has been computed by the above method from it, that loss may be determined with no greater difficulty than any other item in the boiler heat balance.

New York City. E. Ogur.

Worn Bearings Cause Noise and Trouble

When I entered a power plant recently where I had been asked to look over some equipment, I had no difficulty in locating the engine room because of the noise made by the machinery. It required no experienced man to detect here one plant that was audibly advertising its defective condition. Worn brasses and faulty adjustments caused the trouble in this case. Neglected bearings usually cause more serious conditions than mere noise; often they cause poor steam distribution in some types of engines. I have met some engineers who do not refit or take up worn bearings until disgraceful conditions actually force them to do so.

Bearings, or the brasses in the bearings, operating the gear on some types of four-valve engines wear faster in connection with the steam valve gear than they do on the exhaust valve gear. This wear is determined more or less by the load and the steam pressure carried. The life of the brasses on this part of the engine can be greatly extended or shortened according to the nature of the lubricant used and the care which an intelligent engineer will give to them.

Only a careless man will neglect to take up the bearings as needed. On crankpins, the wear is practically all around, therefore it takes a long time for them to wear to an elliptical shape but it is a short job to do a little tightening as long as the pin is not worn out of round. It is different with crosshead pins, which wear on both sides and soon assume an elliptical shape if not partly turned to secure a different wearing surface. This should be

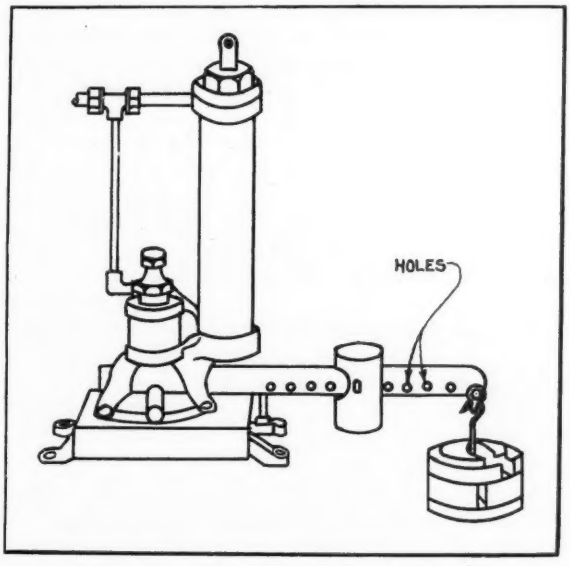
done once every three, six, nine or twelve months depending upon the daily run durations and the load carried by the machine. On vibrating pins in steam valve gears a comparatively small amount of wear will affect the steam distribution, and when the engine is in operation and the two slight ellipses are at right angles to each other, as they swing a little a disagreeable jar or rattle will result which will cause a shudder to run through any man having a real engineer's sense of hearing.

Different methods are used to treat elliptically worn pins and brasses but it is best to give them proper attention and first-aid treatment while they are running and thus obviate the danger of heating, thumping or rattling, which are the ways a bearing uses to complain of unfair treatment.

Toronto, Canada. JAMES E. NOBLE.

Making a Damper Regulator More Sensitive

ONE USER of a damper regulator made along the lines shown in the accompanying sketch recently discovered that he could make the device delicate enough for use on vapor heating systems although it was not originally intended for such systems. By drilling holes along the lever arm,



COUNTER WEIGHT IS HUNG CLOSER IN ON THE LEVER ARM

as indicated, the weight at the extreme right was moved inward thus really making the lever arm shorter. He found, after making this simple change in design, that the regulator operated satisfactorily on exceedingly low pressures.

This is a so-called hydraulically operated damper regulator. The low steam pressure first acts against the diaphragm, which in turn acts against the weighed lever. When the steam pressure is sufficient to raise the weighed lever a pilot valve which controls a supply and discharge of water is opened admitting water pressure into the bottom of the motor cylinder. In this way any desired force may be obtained for operating the damper, regardless of the steam pressure.

Newark, N. J. W. F. SCHAPHORST.

Prevention of Rust in Steel Stacks

IN THE November 1 issue, C. M. A. describes how a steel stack rusted through in four years, and how a gummy material, having an acid reaction and the appearance and odor of burned sugar, has made its appearance on his new steel stack. The probable source of the deposit and one method of preventing it are discussed here.

This deposit was probably sulphate of iron or sulphate of iron mixed with soot; it might have been sodium sulphate or some other sulphate compound.

In the burning of coal there is almost invariably some sulphur impurity in the flue gas, because virtually all the sulphur in the coal is volatile. This gas combines with moisture, which is also invariably present and this combination of sulphurous or sulphuric acid tends to condense on the cooler stack surfaces at times when the fire is being banked, or when the plant is not operating as heavily as usual. This frequently occurs at night and on Sundays. As cold air is drawn in, carrying its humidity, the acid acquires enough moisture to make it attack the metal of the stack readily. This condition is likely to be followed by a period of operation when the stack warms up, the moisture is driven out and the impurities on the stack surfaces are deposited.

All steel stacks are lapped where they are riveted; thus a crevice is left on the inside, in which deposits of various kinds may settle and in which moisture can condense and run down the stack, causing rapid deterioration at the seams. Considerable protection can be given to a steel stack exposed to rainfall and to the action of chemicals and gases, by coating it with a chemical preparation made especially for this purpose by the Dearborn Chemical Co. Of course the success of this protection depends on the conditions under which the stack is operating; however, if the stack described had been coated inside when it was new, with the preparation mentioned, and the seams covered with it, the corrosion probably would have been prevented and the life of the stack considerably increased, although it is difficult to say how much.

Chicago, Ill. D. K. FRENCH.

Starting a Stuck Piston

IN PUTTING a set of Rollins packing on an engine, it was necessary to take out the piston. But after stripping the engine, removing nuts and washers, we found that the piston was stuck on the rod. No amount of pulling or pushing would start it. We hooked a chain-fall to the crankpin and pulled. We rigged a driver and lead cushion and pounded. But still the piston stuck.

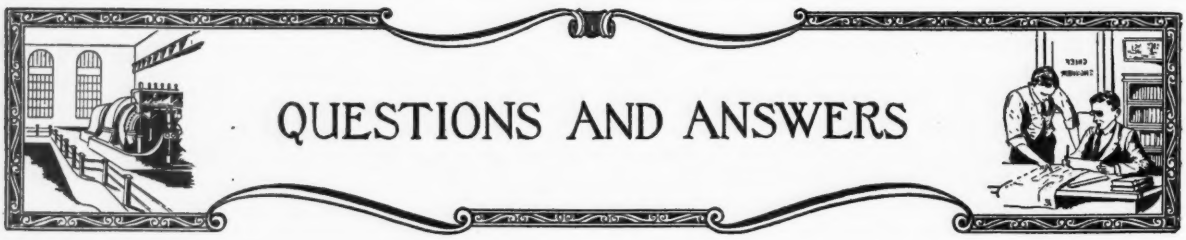
Finally we tried heating the piston with two gasoline torches placed against the spider. After heating it about an hour, we tried it again. This time the rod went flying and we soon had the piston out.

Then we discovered the cause of the trouble. Some time before, the nut had worked loose and had been scored. When it was tightened up, moisture got under the nut in the scored places and caused rust.

This job took all night and for a while it looked like a case of shut-down, but next morning the engine was running as well as ever.

Utica, N. Y. M. M. BROWN.

THE YELLOW streak may be clay or pay-dirt. Dig before you stake.



Calculating Width of Gear Teeth

IN REPLACING a 200-hp. engine running at 82 r.p.m. with a 200-hp. motor running at 590 r.p.m. it will be necessary for us to use two sets of gears as shown in Fig. 1 to get the necessary speed reduction. It is proposed to use gears as shown: first set, pinion 24 teeth, gear 64 teeth;

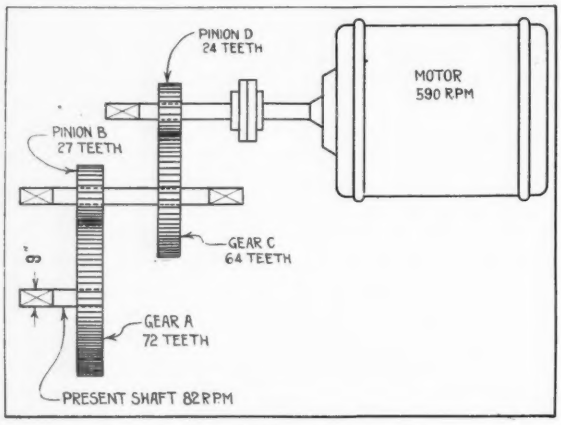


FIG. 1. PROPOSED GEAR TRAIN

second set, pinion 27 teeth, gear 72 teeth. Please explain how to calculate width of face of gears, pitch of gears and proper size of shafting to use. J. B. P.

A. Usually the term pitch of a gear means the diametral pitch, which is a ratio found by dividing the number of teeth on the gear by the number of inches in the diameter of the pitch circle of the gear; that is, if the pitch circle diameter of the 72-tooth gear is assumed to be 36 in., then the diametral pitch of the gear is 2. In other words for each inch of pitch diameter, there are two teeth on the circumference of the gear. Circular pitch, on the other hand, is a dimension in inches, measured on the circumference of the pitch circle, as shown in Fig. 2-A and expresses the actual distance between a point on one tooth and the corresponding point on the next tooth.

As the gears revolve, the pitch circles are theoretically in contact as shown in Fig. 2-A. The part of the tooth that projects beyond the pitch line is called the addendum, which is found by dividing 1 by the diametral pitch, or by dividing the circular pitch by 3.1416. Thus, if you know the pitch of a gear, you can compute its pitch-circle diameter by subtracting 2 times the addendum from the outside diameter of the gear.

In the following formulas the relations between diametral pitch and circular pitch are shown:

diametral pitch = number of teeth ÷ diameter of pitch circle

circular pitch = diameter of pitch circle × 3.1416 ÷ number of teeth

= 3.1416 ÷ diametral pitch.

It can be seen, therefore, that when only the number of teeth is given, to find either the pitch of the gear or the diameter of the pitch circle, one of those two must be assumed.

If we assume that the diametral pitch of all the gears is 2, then the diameter of gear A (Fig. 1) is 36 in.; of B, 13½ in.; of C, 32 in. and of D, 12 in. The following formula has been developed for involute gears:

$$P = f \times F \times T^2 \div (6 \times L)$$

where P = safe static load in pounds acting at pitch line
F = width of face in inches
T = thickness of tooth at root in inches
L = moment arm in inches
f = allowable fiber stress

Figure 2-B shows how P acts to produce the maximum strain on the tooth; this strain is resisted by the section

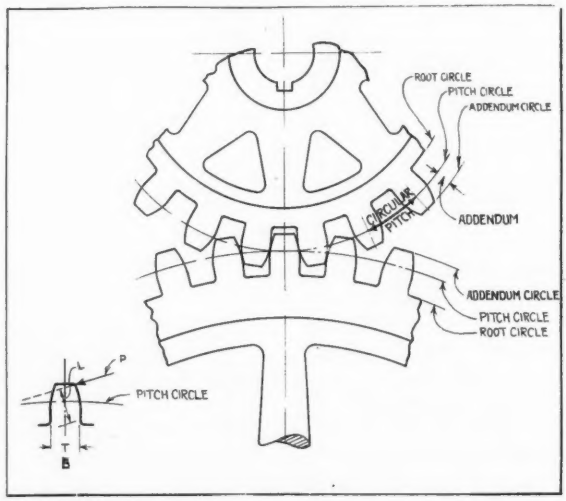


FIG. 2. GEARS IN MESH, SHOWING TOOTH DETAILS

at the root. Various tables have been prepared, from experiment with various sizes and shapes of gear teeth, giving values of P per inch width of face per 1000 lb. safe load, for different values of L and T. In addition, the pitch-line speed must not be allowed to go above a limit of 2000 ft. per min. and the allowable fiber stress in the above formula must be multiplied by a coefficient which will reduce the allowable stress as the speed increases.

In the case of pinion D, for example, the pitch-line speed is 3.1416 × 11 × 590 ÷ 12 or 1780 ft. per min., 0.22 being the corresponding coefficient. The total load to be sustained by a tooth of this pinion is 200 × 33,000 ÷ 1780, or 3710 lb. The allowable fiber stress is 8000 × 0.22, or 1760 lb. per sq. in.

From a table which has been prepared, the value of P for one inch of face and 1000 lb. safe load is given as 149. Then 3710 = 149 × 1.76 × F from which F = 10.4 in.

It can be seen that the pinion will be badly proportioned. The width of face is usually made 2 or 3 times the circular pitch, which in this case would equal 4½ or 5 in. Furthermore, the pitch-line speed of 1780 ft. per min. is so near the limit that whining, lubrication troubles and excessive tooth strains are likely to result. If the diameter of the pinion is increased, the width of face can be reduced, but the pitch-line speed will be increased.

Considering all these things and considering also the fact that your reduction from driving pinion to driven shaft is about 7 to 1, we believe that a chain drive or a herringbone gear drive should be considered for this case, instead of the gear train. Either of these drives would be direct and would give less operating trouble, although the first cost would be higher.

To find the size of shaft needed for gear C and pinion B, the following formula, which allows for bending and torsion, may be used:

$$Hp. = D^3 R \div 125$$

in which D is the shaft diameter in inches and R is the speed in r.p.m. To transmit 200 hp., then, the necessary shaft diameter at 222 r.p.m. (the speed of the intermediate shaft) is 4.8, or 5 in.

Safe Rim Speed for Split Flyweel

On our Corliss-driven ice machine we have a balance wheel whose dimensions are as follows: diameter 12 ft.; face of rim, 10¼ in.; thickness of rim, 11¼ in.; diameter of hub, 21 in. mounted on an 11-in. shaft. The wheel is made in two sections, the hub being clamped to the shaft by four $2\frac{7}{16}$ in. bolts and the rim joint being held by a 2-in. bolt and a 14¾-in. by 2-in. link on each side of the rim.

1. How can we figure the safe rim speed for this wheel?

2. If a wheel wobbles, how can it be made to run true?

3. How should our wheel be secured to the shaft to get it lined up correctly?

4. Should the hub and rim bolts be heated before being tightened in place? O. W. N.

A. Several methods are used for figuring the safe rim speed of a split flywheel. Some engineers prefer to design it as a solid wheel and to make the strength of links and bolts equal to that of the rim. Others prefer to consider the joint the weakest point and to use a coefficient determined by experiment and depending on the efficiencies of various types of joints. We shall use the latter method here.

The safe rim speed of a flywheel is determined by the weight of the material per cubic inch, the tensile strength of one square inch of the material and the efficiency of the link joints. A rim speed of not over 6000 ft. per min. is considered safe for a flywheel with a solid rim. When the rim is split, this speed must of course be reduced. The following formula, developed by the flywheel department of the Fidelity & Casualty Co. gives the maximum allowable rim speed as

$$V = 1.6\sqrt{[S \div W]}$$

where V = maximum allowable rim speed in ft. per sec.

W = the weight of the material per cu. in.

S = the tensile strength of the material per sq. in.

Therefore for a cast-iron wheel with a solid rim W = 0.26 lb., the tensile strength for cast iron is taken as 10,000 lb. per sq. in. and $V = 1.6\sqrt{[(10{,}000 \div 10) \div 0.26]}$ the 10 being the necessary factor of safety.

It is considered best, however, in the case of a link-joint wheel, to design according to the efficiency of the joint. The Fidelity & Casualty Co. gives the efficiency of such joints as 0.6 that of the metal in a solid rim. Therefore, the tensile strength should be 0.6 of that given above and the formula becomes

$$V = 1.6\sqrt{[(10{,}000 \times 0.6) \div (10 \times 0.26)]}$$

from which V = 77 ft. per sec. maximum allowable rim speed.

On a 12 ft. wheel, a point on the rim goes $12 \times 3.14 \times n$ ft. one minute, from which n = 123 r.p.m.

Another but somewhat more complicated method of calculating this speed uses the centrifugal force developed by the rim and the resistance of the joints. We feel, however, that the method described above is as good for practical purposes. It can be taken as a safe rule that the rim speed should not exceed a mile a minute.

2. If the flywheel about which you are asking is on a new engine, the alining of the wheel should have been done by the engine builder and if upon erecting it is found to run out of true, the matter should be reported to him at once. On the other hand, if the engine is an old one and has been in use for some time, a sprung shaft, loose bearings or pillow block, loose foundations, loose bolts on hub or drum might cause the wheel to wobble. Sometimes when a wheel is taken off for repairs, shims are put in when it is replaced and if these shims work loose or are put all on one side, the wheel may run out of true. Of course, it is almost impossible to get any wheel to run perfectly true.

3. In putting the split wheel in place, it is advisable to lower half of it into the pit before the shaft is put into the bearings; this half should be blocked tight against the shaft, the other half lowered on it, and the two connected by the hub bolts, which are generally heated before insertion so that they will contract and give a good grip. The hub should be bored 2 or 3 thousandths of an inch smaller than the shaft and a space of half an inch should be allowed between the halves for clamping. A feather key secured in the shaft and well fitted on the sides of the keyway in the hub is better for a split wheel than a driven key. Next the rim bolts are put in. The links are heated until they expand from $\frac{1}{32}$ to $\frac{1}{16}$ in. longer than the recess and are put in last.

4. It is customary to heat links, rim bolts and hub bolts in such cases. This, of course, produces an initial tension in them as they cool and tighten up but as they are designed to take this, no harm will result.

Can This Pipe Covering Be Repainted?

When installing the piping in our plant, the contractor painted all the pipe covering with asphaltum paint. Now we wish to paint the covering gray and white, but when we try it, the asphaltum paint shows through the lighter color. Can anything be done to prevent this, so that we can get a good finish? G. A. K.

One way to win an argument is to keep your temper and get the other fellow mad, for anger invariably defeats its own purpose.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Some Ways to Eliminate Waste

More and more industry is realizing the necessity for the utilization and elimination of waste. Being able to reflect (somewhat bitterly) on past prodigality we are taking long strides to the end that posterity may not so reflect upon us.

Utilization of waste is interesting as well as profitable. Up to the present time we threw away, as waste, about 80 per cent of our slate production. Now, we pulverize it and incorporate the slate flour into rubber goods. It affords greater durability for such products as boots, heels, tires, etc.

C. B. Auel, in his talk before the Society of Automotive Engineers in Detroit recently, cited some simple ways in which all may do something to eliminate waste. His points are worthy of repetition. They are:

"Files, when they become dulled, can be resharpened by means of a suitable sand blast and again used to excellent advantage, giving in most instances every bit as good service as new files.

"Misprint or other defective product bags can be purchased and used about a plant as carriers for small parts. They are cheap, capable of being used again and again and, with their ability to conform their shape to their contents, are to be preferred as carrier or storage containers to other types.

"Used sugar bags, opened at the seams and washed, make the finest kind of wiping cloths. For polished surfaces they are superior to cheese cloth or canton flannel because they are free from lint and in most cases cheaper.

"Short drills may be turned into counterbores.

"Short ends of wood may at times be disposed of to manufacturers of brushes for brush backs.

"Sawdust makes an excellent material for packing purposes, as well as a good extinguisher for small fires.

"Regular inspection of all air, water and steam lines and of air hose, of tools for leaks, and of lights left burning needlessly, will invariably pay for itself.

"Near-white and colored rags may be substituted for cotton waste and when soiled can be sent to laundries and washed on the basis of a regular price per pound.

"Self-closing faucets, especially for hot water, will prove an economy in all plants."

Says Herbert Hoover:

". . . . But I may say at once that if the American people have not the intelligence, if they have not the character, if they have not the political mechanism by which private competition can be maintained and yet abuse can be prevented, then they do not possess the character or the political mechanism by which they can undertake the gigantic operation of these enterprises." (Mr. Hoover was speaking before an audience of railroad men.)

Financial Benefits as Well as Moral Reasons

When we learn that the Beaver Valley Traction Company reduced their accident-compensation costs $24,000 in 2 yr., simply through the use of safety equipment and the spreading of safety propaganda, we have incentive to look up the total of our own costs.

When we know that by the same means the Texas Power & Light Co. cut this item from $60,000 in 1920 to $2,000 in 1923, safety work takes on a new color. For profit seats itself beside our philanthropic motive.

Of the 209 daily deaths by accident in the United States, 36 are due to falls and stumbles. The majority of these fatal stumbles are industrial. Every one of them causes suffering for the victim's relations and a financial loss for the employer.

How recently have you toured your plant with the single intent of inspecting safety appliances and looking for places where additional safety measures should be taken? Such tours have a dollars and cents value.

Who Will Make Up the Deficit?

In California, the state revenues obtained from corporation taxes amount to nearly 10 per cent of the state's gross income.

Advocates of government ownership of public utilities tell us their plan would effect a "saving to the people"; a "reduction in taxation."

Putting the public utilities under government ownership would take the electric light, the power, the gas producers; the telephone, the telegraph and the railway operators out of the taxable lists.

Who, then, would make up the 10 per cent?

Short Cuts From Other Offices

In the general office of the Shotwell Company, Chicago, there hangs a large hand-painted poster entitled "Stop the Leaks." It tends to build esprit-de-corps worth much in dollars and cents. We quote:

"If you know where there is a 'leak' in this business —report it. If you know where a dollar can be made or saved, it is your plain duty to speak up. Let's work for the good of all."

Interesting Developments in Other Fields

Four years ago there were no broadcasting stations. Today there are 530 in operation. During 1920 the sale of radio apparatus was less than one million dollars annually. Now, it exceeds one million dollars a day. The radio industry provides employment for over 200,000 persons and it is estimated that the radio audience is in excess of twenty millions. A method whereby ships can be directed entirely by radio has been perfected. In future, airplanes may carry Montana wool and Georgia cotton to the New England textile mills—without a man on them. They will be guided by radio—dispatched by one station and caught by another.

A newly perfected ultra-audible microphone now detects and amplifies insect voices. This opens up to us a whole world of sound for entertainment and practical purposes. In the mining industry they are using an instrument that will record voices or similar sounds through a quarter-mile of solid rock. It has already done much to aid those in search of miners trapped by cave-ins.

Plants exposed to electric light at night have grown to twice the size of those subjected to daylight alone. Another scientist has perfected a means whereby he can reserve, indefinitely, perishable food of almost any kind. He accomplishes this by placing the food or fruit under specially constructed glass, through which the sun's rays act as the preservative. For the length of the experiments thus far carried forward, the odor, color and flavor of the perishable foods have remained unimpaired by decay.

Seed oysters are now being propagated in a hatchery much the same as trout, which, heretofore, was considered an impossibility.

How the Wealth of the United States Is Distributed

Total wealth of the United States as calculated by the National Industrial Conference Board is $320,800,000,000. The figure given represents our wealth as of January 1, 1923. This gives a per-capita wealth of $2,918.00.

This total is divided into two classes, viz: "real property" and "other wealth." "Real property" includes all real estate, buildings and fixed improvements, and assumes 55 per cent ($176,400,000,000) of the total. "Other wealth," which includes railroads, public utilities, manufactories, agricultural implements, produce and live stock, personal property, etc., makes up the balance. Our wealth in railroads and public utilities is estimated at $35,400,000,000; our manufacturing industries at $44,200,000,000; agricultural equipment, produce and live stock at nearly 14 billions and the nation's personal property at nearly 44½ billions of dollars.

As against 1900 our national wealth has increased nearly four times, the estimate at that time being 88½ billions. In other words, our real property of 1922 alone is twice our entire national wealth as of 1900. And although every division into which our wealth is sub-divided has increased since 1900, in percentage of the whole our railroads and public utilities together with agriculture have declined.

In 1900 our railroads and public utilities comprised 14.2 per cent of our total wealth. In 1922—11 per cent. Agriculture, in 1900, constituted 6.2 per cent of our national wealth, whereas in 1922 that division was slightly in excess of 4 per cent. The division of "manufacturing equipment and products" increased from 9.8 per cent in 1900 to 13.8 per cent in 1922. The increase in this division coupled with the decrease in agricultural wealth is proof that we are rapidly becoming an industrial rather than an agricultural commonwealth.

Rubber as a Bearing Surface

To one acquainted with rubber only as it is used in automobile tires, bands, and other fabricated products, it would not seem an efficient substance for bearings. Engineers, however, after years of research, found that rubber can be successfully used as a bearing liner. Indeed, a few manufacturers have already adopted rubber bearings as standard equipment on such machines as pumps, compressors, etc. An experiment with rubber bearings was made in a marine engine with the result that, after nearly a year of constant service, neither the bearing nor the shaft showed any indication of wear.

In using rubber as a bearing liner, water, not oil, is employed as the lubricant. Oil acts detrimentally on rubber and cannot be used. This change is, however, a source of economy. As in the case with metal bearings, the rubber is provided with a spiral groove to aid lubrication. Through this groove a stream of water passes, carrying with it any sediment or grit which may have found its way into the bearing.

It is said, also, that sand or grit will not cut a rubber bearing. It seems that such foreign substance will embed itself in the rubber, eventually working itself out without scratching or doing damage to either bearing or shaft.

Rubber bearings have been used successfully on both high and low-speed shafts and it is reported that loads as high as 375 lb. per sq. in. have been efficiently carried by such bearings.

Somewhat surprising is the statement made by experimentors, that the friction coefficient of steel is considerably less on water lubricated rubber than on oil lubricated metal. Other advantages are the reduction or elimination of such ordinary defects as pounding, vibration and misalinement.

A Nation of Faddists

In social, commercial and industrial affairs we are prone to fads, only we hesitate to admit it.

Mah Jong, bobbed hair, appendicitis, police dogs, jazz, are all fads, more or less insecure. But these surface eruptions do not effect anything more serious than a possible shortage of ink and news print paper for their public discussion.

Far more detrimental are political and industrial fads. During 1919 and 1920 there was much talk about the need for greater production. The pendulum of industrial expansion swung to the extreme, the detrimental effects of which we still feel. Just now it is a fad to say that people do not work hard enough. Few things give the individual more pleasure than the remark that we (the one making the remark) will not get along properly until people (everybody else) are willing to work harder. We sometimes wonder if all of us are not more deficient in hard and right thinking than in hard and right working.

Perhaps the most dangerous of all present day fads is amending the Constitution. According to James A. Emery, of the National Association of Manufacturers, 3163 proposals for Constitutional amendments have been offered during our 134 years of national existence. This is at the rate of about 24 a year.

During the last session of Congress it is said that considerable more than one hundred constitutional amendments were suggested. They covered everything from national blue laws to national marriage and divorce laws.

The Constitution ought to be our most stable statute. Certainly, our forebears who drafted it, intended it so to be. If an economic or moral ill is grave enough to require the doubtful remedy of legislation, Congress or the various states should apply that remedy. But we should go slow on the Constitution.

IN LINCOLN'S time it was necessary to read one book 100 times. Now we have 100 books which we read once. We do not advocate a return to the conditions prevailing in 1840. But, to read one book 100 times and understand it is better than to read 100 books once and not understand them.

EDITORIAL COMMENT

Executives Want to Save Dollars, Not Heat Units

In the industrial plant, the operating engineer often feels that the factory management regards the power plant as a necessary evil, something to be put up with for want of a better method of turning the wheels in the production departments, but something on which no money is to be spent except in a case of dire necessity. The plant engineer feels this most keenly when he approaches the management with a request for new equipment that will raise the efficiency of his boilers and engines. He finds that the management often has little patience with his troubles and he cannot understand why, because his needs are so evident to himself.

The reason for this apparent lack of interest will be clear when we consider that the executive thinks in terms of business and finance, not engineering. He thinks of the total cost of the factory's product, of first costs, interest on investment, fixed charges, depreciation and the like. If he is not an engineer himself, the executive thinks of the power plant simply as a place from which to obtain as cheaply as possible the power necessary to turn the wheels of the production departments.

Yet this very attitude taken by so many executives gives the engineer a chance to show the management that here in the power producing department is an opportunity to cut costs that has too often been overlooked. The principles of good salesmanship apply here. The proper stand for the engineer to take is that the question is one of business policy, that by investing a definite amount of money in equipment carefully selected to decrease the fuel consumption and pay for itself within a definite time, a material reduction can be made in the cost of supplying power. An approach to the subject from this viewpoint will arouse the instant attention of the executive whereas the recital of technical woes often leaves him cold.

It goes without saying that in presenting his case in this way, the engineer will be prepared to prove his point, like any other good salesman. For example, if he needs a new feed-water heater, he can find out without much trouble how much the heater will cost, the depreciation on it, the cost of maintenance, the interest on the investment, and the fuel saving that will result from its use. Then he can show how in a definite time, considering past averages, the saving will pay for the heater and how, after that time, the power cost will be reduced by just that much, allowing of course for the replacing of the heater at the end of its life.

In attempting to raise the efficiency of his plant, the engineer can secure the interest and co-operation of the management if he will remember that they are primarily interested in saving dollars, not heat units or power units. Without too much trouble, he can translate his technical information into business terms. When he does this, he finds that, after all, the management is interested in his work.

Development Is the Result of Demand

No conscientious manufacturer claims that his product has reached the stage where it cannot be improved. In most cases competition is so keen that in order to keep his products on the market he strives for continuous improvement. For this reason manufacturers are always on the lookout for possible ways in which their products can be made to serve their customers more completely. This is not always easy, particularly when the equipment has undergone much improvement and refinement through years of use.

Equipment installed in power plants is made to serve a particular purpose and it is the man who has direct charge of the equipment who knows best whether or not it is functioning properly. Manufacturers must look to their customers for suggestions whereby products can be made to serve their purpose better.

Less than a generation ago, the consulting engineer who did not design the principal units especially for each plant was rare; today, however, this responsibility is thrown upon the manufacturer and this practice has resulted not only in less expensive equipment but more uniform practice throughout the entire country with decidedly higher operating efficiency generally.

As a rule manufacturers have developed standard products which can be made much more cheaply than special designs. When, however, the demand becomes pressing, the progressive manufacturer is quick to recognize the advantages of modifying his standard design to meet the service requirements. In fact, progress in engineering equipment has been the answer to demands made upon manufactures for equipment which is needed to increase the economy of the power plant. The industry will be benefited, if engineers will more frequently point out their needs to manufacturers and co-operate in the development of equipment to meet these needs.

Results Count

Employers are constantly on the lookout for men who can get results. These men have the characteristic of aggressiveness and the ability to put ideas into practical operation. They are the men who can be depended upon to hold steadfastly to an ideal and thus they increasingly enhance their value to the company by which they are employed.

Of late years a great deal of pseudo science has been practiced in the so-termed technique of selecting men according to types or character analysis. Men have been broadly classified into; the executive type, the promotional type, the selling type, the clerical type and the mechanical type. This is much like tagging a motor "for fan drive only"; when in fact it may have and usually does have a thousand or more useful applications. Some motors can be cut off the line, driven by some external power and they will then generate electricity.

It is much the same way with the man who will apply himself. It is doubtful if he can be tagged and labeled. Give him an opportunity to fit himself into new conditions and it will not be long before his energy will be felt even though it may be directed in a somewhat different channel from that which it had been traveling.

Apprentices are expected to develop into oilers and from oilers into operators. From somewhere in this group must come a chief engineer and possibly a purchasing agent; several manufacturing department heads will also come from this group and it is not uncommon to find that the president, or even the chairman of the board of a company, has risen through these various steps.

Men of this type have been aggressive and practical. They have held to an ideal, no narrow classification will define them. They are not the type of men of whom it may be said "their intentions are good" or "they mean well." They are the men whose intentions are carried out into facts and their meaning is always clear and well defined. They are the men who get results.

More Safety Education Is Needed

That industrial accidents have increased 29 per cent during the past thirteen years, in spite of the steadily increasing amount of safety work done in that time, is the surprising condition revealed by recent reports of governmental and private investigations. These surveys also show that nowadays not more than one-tenth of all accidents can be eliminated by improvements in machinery, and that prevention of the remainder depends on education and supervision.

Keeping this fact in mind, the power plant engineer can aid materially in reducing the accident toll. Some sort of organized campaign, using bulletins, posters and charts, should be used in the power plant to keep constantly before the workman the necessity for care at all times, not only on his own account but also for the sake of his family and his associates on the job. Attention to any process involving possibility of accident and personal investigation of an accident to discover its cause and take steps to prevent a recurrence of it will also help the engineer to reduce the loss from this source and will improve the morale of the plant.

Improvements in machine design for the protection of the workman have resulted chiefly from the interest and initiative of the engineer. In the important work of safety education, we believe he will continue to exert all the influence at his command.

Off Duty

You are all, perhaps, familiar with those newspaper stands where one may buy newspapers published in various cities throughout the country. They are to be seen on certain street corners of most of our towns and cities and in passing you have all, no doubt, glanced at these stands, wondering whether they were a paying proposition —whether a sufficient number of people were interested enough in papers two or three days old from other cities, to make the business profitable. Old news is no news, and unless a person is in search of specific information or is actuated purely by reasons of local interest, he will not be likely to buy such papers.

If, however, we could buy the London Times or even newspapers of distant cities in our own country on the same day or perhaps a few hours after they were published in their respective cities, we believe these newspaper stands would become considerably more popular.

Imagine, going down to work in the morning and buying, in addition to your own local paper, the same morning's edition of the "London Times" complete in all its detail and with all its pictures. Don't you think that would be interesting? Interesting, you say, to be sure, but why waste time dreaming about such things—on the face of it, its an impossibility. How could we possibly transport newspapers with such rapidity?

The realization of this dream, however, is not so far off nor so impossible as it may appear. A few years ago, yes, such an idea would have been nothing more than a day dream. Today, we look at the idea in a different light and while not exactly a reality, developments are under way which may put it on a commercial basis within a short time.

On Sunday, November 30, the first pictures were sent across the Atlantic by wireless. From a hastily set up apparatus in an office in the Strand, London, a score or more photographs were transmitted to the New York office of the Radio Corporation at 66 Broad St. The time for the transmission of each picture varied from 6 to 30 min.

Now, what does this mean? It means not only that we will be able to send photographs and drawings by this method, but also that we have at our disposal a new, rapid means of transmitting intelligence. For, if it is possible to transmit a photograph in all its infinite variation of shade and detail, it should be an easy matter to transmit a sheet of printed matter containing thousands of words. Herein lies the real power of the development.

Suppose, for instance, instead of a photograph, we wrap around the transmitting cylinder of the photoradiogram apparatus in London, a reduced copy of the "London Times." Six or ten minutes later, an exact duplicate of this copy would be available in New York. This could then be enlarged, plates made, and within two hours the newspaper presses in New York could be turning out copies of that morning's "London Times."

With modern, high-speed automatic transmitting equipment, it is possible, by radio, to transmit as high as one hundred words a minute. By transmitting whole sheets of printed matter with the new photoradiogram apparatus, it may be possible to transmit as much as a thousand words a minute, with *absolute accuracy.*

This new development is only one of the numberless possibilities of the radio art, but is one which in time will have a great influence upon civilization. There is an old Chinese proverb that, "One picture is worth 10,000 words." This is as true today as it was the day it fell from the lips of the Chinese sage who uttered it. Since primitive man made his first crude drawings upon the walls of his cave, pictures have been in constant use. One good picture may convey to us in a glance, an idea or story that would require many words in the telling.

Pictures constitute a universal language for all the people of the earth. What the free interchange of pictures across the world will mean, cannot be foreseen as yet but that its influence will be far reaching can not be denied.

It is not too much to suggest that the hurling of pictures across thousands of miles of oceans and continents through the agency of the radio, will play an important part in promoting world peace by making closer neighbors of peoples living on opposite sides of the earth.

Mechanical Engineers Discuss Power Problems

ANNUAL MEETING OF THE A. S. M. E. HELD IN NEW YORK, DEC. 1 TO 4. MODERN TENDENCIES IN ENGINEERING CONSIDERED IN PAPERS ON FUELS, OIL ENGINES AND TURBINES, STEAM EQUIPMENT

AS CHIEF topics of those sessions of the Society which dealt with power problems were found the Use of Oil as a Fuel, Use of Pulverized Coal, Oil Engines, Gas Turbines, Water Treatment and Cooling, Effect of Resuperheating on Turbine Efficiency and Tests on the New Prosser Steam Engine. Of these, the ones dealing with fuels and combustion engines were treated as a resumé of current and recent practice, while those on water handling and steam prime movers were records of the results of investigation and research. In addition there were several reports and hearings of committees on test codes and a process report as to the research for the development of new and more accurate steam tables.

Papers on Storage and Handling of Fuel Oil and on the Hazards of Oil Burning which were presented at the Tuesday and Wednesday meetings are abstracted in this issue of Power Plant Engineering and the paper on Oil Burning will be presented in abstract in an early issue.

POWDERED COAL HAZARDS

Pulverized Fuel was covered in two papers, one by Messrs. H. E. Newell and Robert Palm on the Hazards of such systems, the other by Henry Kreisinger a Review of Recent Practice.

Hazards are chiefly the formation of an inflammable mixture of fine coal dust and air and spontaneous combustion in storage bins or pipes. Methods advocated to overcome those hazards are segregation of the pulverizing plant, construction of fire-resisting materials, avoidance of places where coal dust can lodge, painting surfaces such a color that dust will show when it collects, good housekeeping to remove all such dust without scattering it into the air, good ventilation of bins and buildings, keeping the fuel system tight and removal of all stray iron from the coal by magnetic separation before pulverizing.

To minimize the damage from explosions due to dust, explosion doors, skylights or windows are recommended.

Of the three systems in use, the unit system, pulverizing the coal at or near each burner is considered the least hazardous on account of the short distance that the fine fuel is carried and the little or no powdered coal stored. The system of conveying the fuel to near the burner before mixing air for combustion is next in freedom from hazard because small heavy, piping is used to convey the fuel and it does not carry a combustible mixture. Storage is near the burner. In the third system, where air and fuel are mixed near the pulverizer and the mixture blown to the burner, the hazard is increased because the piping is large, usually with rather thin walls so that tight joints are more difficult to maintain, and these pipes carry an inflammable mixture which may be ignited by a spark or by spontaneous combustion of deposits of dust within the pipes.

In driers, the semi-indirect-fired has an advantage over the direct-fired in that the hot gases come in contact with the fuel only after partial cooling. Possibility of fuel in the drier becoming ignited and carried into the pulverizer must be avoided.

Remote emergency stop control of all apparatus and ample fire extinguishing facilities are essential for safety of operatives.

Mr. Kreisinger's paper contained much valuable data from tests on powdered coal plants and will be abstracted in a future issue more fully than present space permits.

OIL ENGINES

Papers on this subject were presented at the Thursday afternoon session. One by R. Hildebrand dealt with Solid Injection, one by Charles E. Lucke with the Double-Acting, Two-Cycle and one by Lionel S. Marks with Gas Turbines. Mr. Hildebrand reported developments on a 3-cylinder, 4-cycle engine of 200 hp. at 257 r.p.m. using jet injection directly into the combustion chamber and arranged for cold starting. He advocated using only moderate turbulence to mix air and oil, as violent turbulence causes heat losses, indicated by negative work on the indicator card taken when fuel supply is shut off. From experiments he has determined that a fuel spray, contrary to common opinion, will penetrate the whole combustion chamber, hence directly opposed jets gave excessive fuel supply at the center of the chamber, particularly with heavy loads. By offsetting nozzles and forming the piston head with two conical offset cavities, the spray filled the combustion space with jets of as great length as possible, avoiding turbulence and enabling the engine to carry 40 per cent overload with clear exhaust.

For good atomization, the fuel must have sufficient speed as it leaves the nozzle which means that nozzle pressure must rise suddenly when the pump plunger starts and drop suddenly when the bypass valve opens. To secure this an impact fuel pump was designed, each plunger driven by an eccentric whose crosshead strikes the plunger shortly before reaching central position, thus giving the plunger high velocity almost instantly. This allows of the use of a large spray nozzle, giving well atomized sprays, but not so fine as to cut down the spray length. Light hollow steel plungers are used, reducing the inertia and noise.

To avoid loss of pressure from compression and reexpansion of oil, the volume of oil from pump suction to nozzle should be small. This was attained by using the hollow pump plunger as a suction chamber, locating the suction valve in the end of the plunger, using a large bypass valve and wide, short return passages to the suction basin.

As spray valves, the check-valve type, closing toward the pump was chosen, spring-loaded but with a light spring and having a number of flutes to keep it centered so that it always seated evenly. A fluted plug gave the fuel a whirling motion as it left the nozzle, which was found to improve the spray and the combustion.

As essentials to successful operation of the solid-injection engine, Mr. Hildebrand gives: straining or filtering of the oil and so handling as to keep out all dirt after filtering; testing the nozzle with a hand pump to make certain that the check valve is tight before placing on the engine; careful attention to make sure that all parts are in good condition and functioning properly.

Dr. Lucke reviewed the work done on large oil engines, particularly the effort to get large horsepower per cubic foot of piston displacement by increasing mean effective pressure without increasing maximum pressure; by use of high-pressure air for injection and of extra injection air; by supercharging; by special shape of combustion chamber by position of sprayers and by design of spray valve. He also considered maximum diameter of cylinder usuable for very high and for moderate mean pressures without injury to the metal from heat. In addition, he took up the problem of developing a two-cycle engine whose weight shall be, as nearly as possible, half that of a four-cycle of equal power and how nearly the double-acting engine can come to developing the same power in both ends of the cylinder for both four and two-cycle types.

From an extensive descriptive, graphical and mathematical analysis, he concluded that comparative weights per horsepower for a given m.e.p. and piston speed are: For 4-cycle, single-acting, 1.19; for 2-cycle, single-acting, 0.655; for 4-cycle, double-acting, 0.705; for 2-cycle, double-acting, 0.395. These valves were shown to be somewhat in the same ratios as for similar engines actually being built. From an analysis of the forces on frames and bearings, he concluded that the 2-cycle, double-acting arrangement offers the best prospect for reduction of weight per horsepower and increase of horsepower per cylinder. Also for this type, two cylinders will give satisfactory torque when built with shaft loads and sizes comparing favorably with those in steam engines.

Study of losses from friction, compression, scavenging and pumping of fuel showed them to be relatively: For 4-cycle, single-acting 21.5; for 2-cycle, single-acting, 18.4; for 4-cycle, double-acting, 14.84; for 2-cycle, double-acting, 15.07. This relation holds for equal indicated mean pressures in all types, and was derived from study of best data. The conclusion was that the fuel consumption per horsepower-hour will vary inversely in accordance with these values.

As to injury of metal by heat, since heat generation increases with increase of piston speed or of mean pressures, there is a limiting diameter for a given speed and pressure beyond which the metal will be injured, sooner or later, by cracks or burns. To define this limit, data must be had from experience. Burning is sometimes found, similar to the action of the oxygen torch, in the direct path of the fuel sprays. Prevention of heat injury depends on steadiness of heat flow and frequency of heat storage, the first governing mean temperature of the metal, the second the maximum temperature variation of the interior skin of the cylinder. This high variation may result in fine cracks due to expansion and contraction.

Remedies against heat injury may be found in the use of ductile rather than brittle metal, in reduction of temperature of the mass of metal just back of the interior skin, and in reduction of heat variation by increasing frequency of fuel injections. Forged steel for cylinders and pistons and making the steel walls thin are helps; also 2-cycle engines have greater frequency of fuel injection than 4-cycle.

In discussion, Louis Illmer approved the 2-cycle engine but stated that base plate must be 50 per cent heavier than for the 4-cycle because of the reversal of stress. Also that weights should be compared on a basis of $D^2\sqrt{L}$ rather than D^2L where D is bore and L stroke. This makes the 2 stroke weigh 10 to 15 per cent more than the 4-stroke of same cylinder dimensions. Because of loss of 15 to 20 per cent of effective stroke in the 2-cycle engine from contraction of piston-controlled posts, the 2-cycle will have only 1-2/3 times the power of the 4-cycle of equal cylinder dimensions. Loss of power in the crank end of a double-acting engine, due to piston rod, whose diameter is say 1/3 the bore, will be 10 per cent of the power of the head end. For these reasons the total power of a 2-cycle, double-acting engine will be not over 3 times that of a 4-cycle, single-acting engine for the same cylinder dimensions and piston speed. Mr. Illmer doubted the effectiveness of steel liners as they could not safely be made thinner than $\frac{1}{16}$ the bore while cast-iron bushings are made 1/12 the bore, and the difference in heat flow would have little effect. Lubrication is easier for cast iron on cast iron than for steel on steel and an average temperature of 450 deg. F. should not be exceeded at the lubricated surfaces. Heat flow of a 4-cycle cylinder is only $\frac{5}{8}$ that for a 2-cycle and is now so high that the problem must be carefully handled so that this may impose a limit on piston speed.

Gas Turbine Possibilities

The paper by Lionel S. Marks reviewed the brake thermal efficiencies of possible types of gas turbines and discussed their possibilities and limitations. The conclusion reached was that there is not much hope of realizing efficiencies which will encourage attempts to overcome the difficulties surrounding gas turbine design construction and operation.

Water Cooling and Treatment

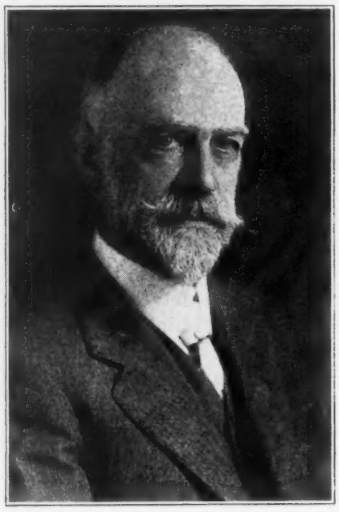
Comparative effectiveness of systems for cooling water, towers, ponds and sprays, was discussed in detail by Victor J. Azbe at the Tuesday afternoon session and Water Treatment by R. E. Hall at the morning session on Thursday.

Mr. Azbe analyzed the parts which radiation, conduction and evaporation play in cooling water, gave charts for the efficiency of towers and spray ponds and a final chart for finding the cooling effect under any given set of conditions. His arguments and conclusions will be presented at length in a later issue. In discussion B. R. T. Collins emphasized that spray ponds must be designed to suit conditions with wide spacing of nozzles and good elevation. Air lanes should be provided so that breezes can carry air through to the center of the system. Properly designed, he thought that spraying will give as low temperatures as towers under all conditions, which was at variance with some of Mr. Azbe's conclusions.

In Mr. Hall's paper, much the same material was presented as has appeared in his articles in Power Plant Engineering. Analyses of various waters and scales, conditions under which scale forms in feed lines and boilers, prevention and removal of scale, corrosive action in feed lines, economizers and boilers, scale and corrosion in steam lines and control of moisture in steam were the major topics discussed. Conclusions were that on proper water treatment depend the prevention of scale, control of corrosion, delivery of dry steam and maintenance of minimum blow-down. Corrosion is chiefly due to dissolved oxygen.

Resuperheating and Turbine Efficiency

To determine the probable gain from resuperheating after partial expansion, the paper by W. E. Blowney and G. B. Warren reviewed the data available on the subject and showed that 6 to 7 per cent may be gained in steam consumption by this process. The range of pressures at



DR. WILLIAM F. DURAND

which the resuperheating may profitably be done is rather broad, but more than two stages of resuperheating is not likely to result in practical economy. Gains from resuperheating and from regeneration are nearly independent and both may be profitably used in the same turbine, with savings nearly additive.

Additional advantages are the use of a smaller condenser because of less heat in the exhaust steam and increase in the capacity of the turbine.

Prosser Steam Engine

This engine, as described in a paper by L. V. Ludy, uses superheated steam and steam jacketing of cylinder, heads, piston and rod to reduce the transfer of heat between initial and exhaust temperatures without doing useful work. Details of design and construction will be given later. Tests were made with a constant valve setting with vacuum of 21 in. and with back pressures atmospheric, 3 lb. and 7 lb. gage. initial pressure being 133 lb. gage steam dry and steam superheat 100 deg. F. in different tests. Full data of tests were given in the paper for loads from 30 to 160 indicated horsepower, and showed minimum steam consumptions at 100 hp. and 21 in. vacuum of 14.55 lb. for superheated steam, at 120 hp. and atmospheric exhaust of 17.42 lb., at 120 hp. and 3 lb. back pressure of 18.22 lb., and at 120 hp. and 7 lb. back pressure of 20 lb.

Final hearing was given on the test code for Solid Fuels and progress hearings on those for Speed-Responsive Governors and for Gas Producers.

Notable as a step in progress was the Zoelly steam turbine locomotive of which detailed description was given by its inventor. Test runs indicate a great advance in economy and flexibility over the reciprocating locomotive while avoiding the great expense for transmission lines of the electric system.

At the business meeting, Dr. William F. Durand of Leland Stanford University was declared elected president for the coming year. Social events included a smoker in the Societies Building, dinner at the Hotel Astor and numerous excursions and luncheons.

Dr. William F. Durand, the new president of the American Society of Mechanical Engineers, was born in Bethany, Conn., March 5, 1859. Graduating from the United States Naval Academy in 1880, he was for 7 yr. in naval service, attached to the engineer corps. In 1887 he became professor of mechanical engineering at the Michigan State Agricultural College, and in 1891 was appointed professor of marine engineering at Cornell University. From 1904 until June of this year Dr. Durand was professor of mechanical engineering at Leland Stanford, Jr., University.

In 1917 Dr. Durand was in Washington as chairman of the National Advisory Committee for Aeronautics and vice-chairman of the National Research Council Committee on Engineering and spent the following year in Paris as scientific attache to the United States Embassy, representing the National Research Council, maintaining an interchange between Paris and Washington of technical and scientific information relating to war problems. He was also a member of the Interallied Commission on War Inventions.

Dr. Durand has written three books, the latest of these, Hydraulics of Pipe Lines, being published in 1921. More than 100 technical papers by him have been published in Government reports and the technical press.

Dr. Durand has been a member of the Society since 1883, serving as vice-president from 1911 to 1913.

Methods of Rating Rivers

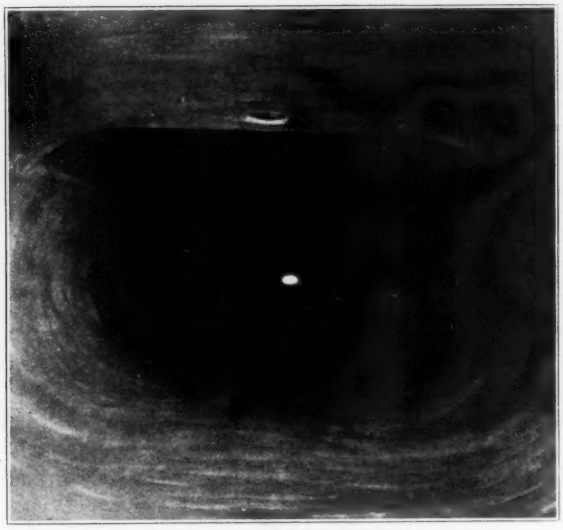
U. S. Geological Survey has proposed to the American Engineering Standards Committee that a national agreement be worked out on methods of rating the water power of rivers. In the request the Survey states: "The engineers of the Geological Survey have struggled with the problem of rating rivers . . . and have within a few years adopted the rule of rating on the basis of 50 per cent and 90 per cent flow. This rule has been adopted by other organizations but is by no means universally used. There is therefore much confusion in statements relating to the capacities of rivers for developing power and a real need for the adoption of a standard. The necessity for a standard was obvious at the World Power Conference in London, as statements of power resources for different countries were made on different bases and therefore were not comparable."

In response to this request the A. E. S. G. will communicate with other organizations which may be interested and if the general sentiment is in favor of the undertaking, a sectional committee will be organized for the work. Expressions of opinion on the subject are invited by the American Engineering Standards Committee, 29 West 39th St., New York City.

Insulated Stack Is 402 Ft. High

IN THE building of such modern structures as hotels, office buildings and hospitals, the steel smokestacks generally run up inside the building and through the roof. Building and fire ordinances require insulation of some kind under these conditions. What is believed to be the highest steel stack of this nature to be insulated, up to this time, is in the new Book Cadillac Hotel now under construction in Detroit, Mich. This stack is 402 ft. high, passing through the building (which is 32 stories high) and extending some 20 ft. above the roof.

The accompanying illustration shows this stack lining in place at the Book Cadillac Hotel, viewed from the base of the stack. The lower part of this lining consists of 2½ in. of Sil-O-Cel Insulating Brick (the upper portion being 1½ in. thick) anchored to the steel by means of welded tie wires as well as a strong sticking cement which forms the insulating brick into a solid monolithic structure.



LOOKING UP THROUGH THE STACK OF THE BOOK CADILLAC HOTEL

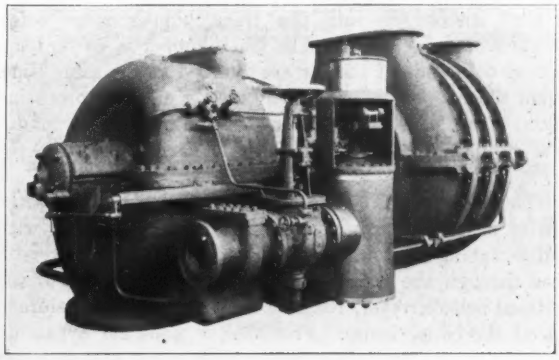
Further anchorage is afforded by wire mesh drawn over and tied into the insulation. Thus three definite forms of anchorage for the insulation are provided. The insulating brick are faced on the inside by ½ in. of refractory insulating cement which forms a dense, hard surface for resisting the erosive and corrosive action of the stack gases.

Centrifugal Compressor for High Pressure Service

MULTI-STAGE, centrifugal compressors, designed to supplement the line of single-stage machines recently developed, are a new development of the General Electric Co. These compressors have been especially developed for furnishing various volumes at higher pressures than ordinarily obtained with single-stage machines. They will find their greatest applications in blowing blast furnaces, Bessemer converters, gas boosters, gas exhausters, in pneumatic material handling systems, in the agitation of liquids, etc.

The main line of compressors covers water-cooled machines designed to deliver volumes of from 3000 to 60,000 cu. ft. per min., at pressures up to 30 lb. or more. The line will also include two types of miniature, self-cooled machines designed to deliver volumes of from 250 to 1400 cu. ft. per min. at pressures of from two to six pounds. All types are to be equipped with either motor or turbine drive.

Among the advantages claimed for the new compressors are higher efficiencies, simpler and stronger construction and minimizing of mechanical difficulties. A larger cooling capacity is expected to bring about greater efficiency, the conversion passages having been improved and the interstage passages simplified. Each complete unit has four bearings with an automatically lubricated flexible coupling.



MULTI-STAGE COMPRESSOR CONNECTED TO A THREE-STAGE EXTRACTION TYPE STEAM TURBINE

These bearings are supported by the foundation or base under the machine. In addition to these changes, all the various governing devices for these machines have been improved, including constant volume governors, constant suction governors and constant pressure governors.

This new line of compressors is the result of a great deal of research work, extending over a number of years. Work has been in progress and machines have been made singly for some time, but the full line has just recently been rounded out and announced on the market.

Among the installations which have been made of the new machines are two 45,000 cu. ft., 25-lb. pressure units at the Mystic Iron Co.; a 6900, a 12,000 and an 8200-cu. ft. machine for pressures of 27, 63 and 28½ lb., respectively, at the Gillette Safety Razor Co.; an 8300-cu ft., 16-lb. machine for the Metropolitan Utilities District of Omaha; two 8500-cu. ft., 16-lb. machines for the Utica Gas & Electric Co.; an 8000 cu. ft., 70-lb. machine for the New Bedford Gas & Electric Co., and four 25,000-cu. ft., 35-lb. machines for the Public Service Corporation of New Jersey. All of these are turbine driven.

New Station Completed in Kentucky

COMPLETED in less than one year, the new $3,500,000 steam generating plant of Kentucky Utilities Co. at Pineville, Ky., adds another link to the physical properties of the Middle West Utilities group. When placed in operation, the station had an initial development of 15,000 kw., but the plant has been so equipped as to provide an ultimate capacity of 30,000 kw.

The new Pineville plant is located on the Cumberland River, making possible the combination of water power

and steam generated power, to supply the needs of the 61 cities served by the Kentucky Utilities Co. Housed in a structural steel and brick building is the first of two 15,000-kw. steam turbo-generators. Provision has been made for a second generator of the same capacity.

Steam at this plant is now furnished by six 1000-hp. Stirling boilers, each with 10,000 sq. ft. of heating surface, and 5500 sq. ft. of super-heater heating surface. The boilers are equipped with Sanford-Riley underfeed stokers, with individual motor drive. The stokers are fitted with both induced and forced draft fans.

Ordinary run of mine coal is received at the central station of the utilities company, from nearby mines, in hopper bottom coal cars which are owned by the firm, and is then discharged into the track hopper after being weighed on track scales. The track hopper is 40 ft. long, so that both ends of the car are dumped at the same time. From the hopper coal is fed by means of a reciprocating feeder 36 in. wide by 24 ft. long, driven by a 15-hp. motor, to a 30-in. belt conveyor, having a capacity of 100 T. per hr.

The 30-in. by 120-ft. center belt conveyor delivers the run of mine coal to a Stearns shaking screen, fitted with plates having 1¼-in. perforations, so that the oversize goes through the crusher and the fines go direct to the inclined belt conveyor, running over the top of the storage bin of the boiler house. Provision is made for bypassing both the screen and the crusher when slack coal is being used. The crusher is of a four-roll design and has a capacity of 100 T. of coal per hour. It is driven by a 50-hp. motor. Coal is crushed so that 85 per cent will pass through a 1¼-in. ring and all through a 1½-in. ring. The 24-in. belt conveyor distributing coal in the bunker is equipped with a self-propelled, self-revolving belt tripper, which automatically discharges the coal into a 19 by 183-ft. bunker, having a capacity of 1200 T. of coal. This conveyor is driven by a 20-hp. motor. The coal flows by gravity from the bunker to the stoker hoppers.

Ashes and clinkers are dropped from the rear of the stokers into an ash pit from which they are discharged into the pan-type conveyor, 30 in. wide by 110-ft. centers. The ash conveyor has a capacity of 20 T. per hr., and is driven by a 15-hp. motor. The ashes are discharged into an outside open pit and are then loaded into standard railroad cars by means of a 20-yd. clam shell bucket.

Coal handling equipment was furnished and installed by the Stearns Conveyor Co. and the plant was designed by Sargent & Lundy, Inc.

Asbestos Packed Ash Pit Doors with Self Seating Feature

SEVERAL INTERESTING features are incorporated in a new ash pit door which is made by The Brady Conveyors Corp., Chicago. The construction is unusual in that the door and frame consist of three main parts; namely, the frame, the door and a hinge frame to which the door is attached so that there is a certain amount of flexibility to allow for inequalities in either the door or frame.

Stationary hinge lugs are cast on the frame. The moving hinge lugs are cast on the hinge frame which carries the door by means of four bolts, one through each corner of the frame. Although these bolts extend through both the hinge frame and the door they do not bring the one to bear against the other because a substantial helical spring is placed over each bolt between the door and the hinge frame. The springs thus act as spacers.

Lugs for the two door locks, which are of cam-lever type, are cast on the hinge frame. With this arrangement the locks can be engaged and as they are closed the pressure comes through the hinge frame, then through the springs, which will be compressed and finally to the door. An inequality at any point on either the door or frame will cause one or more of the springs to be compressed more and so allow considerable flexibility for the correct and tight seating of the door.

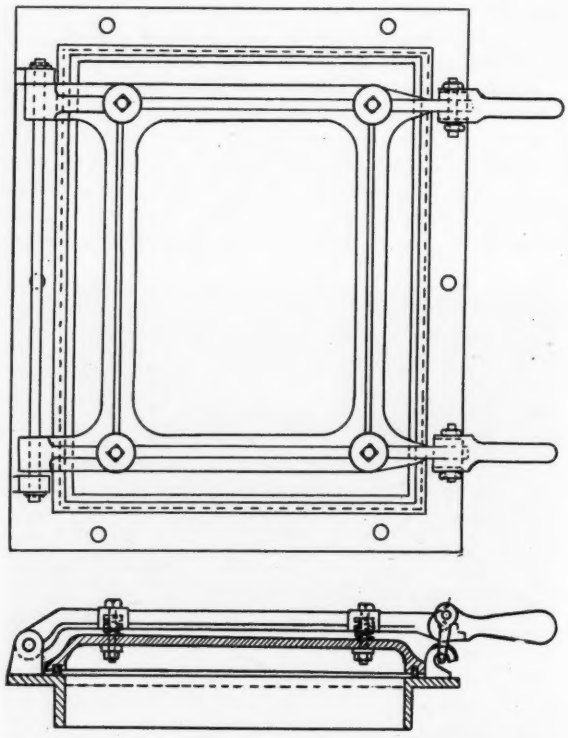


FIG. 1. SPRING SPACERS ARE USED BETWEEN THE HINGE FRAME AND THE DOOR

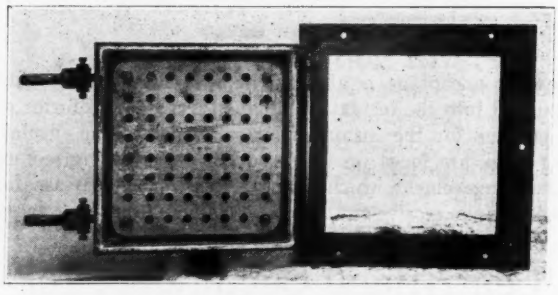


FIG. 2. DOORS MAY BE EITHER LINED OR UNLINED

To assure further a tight fit of the door, the inside edge of the door is cast with a ½-in. square groove into which is pressed a ½ by ¾-in. asbestos packing. The packing projects ¼ in. above the inside surface of the door and is therefore compressed as the door is forced to its seat on the frame.

New Armstrong Trap for Extreme Pressure

THE Armstrong Machine Works of Three Rivers, Mich., has just stepped forward with a new steam trap designed for extreme pressure and temperature. In this latest addition to the Armstrong line the body and cap are of cast steel, having the following characteristics: tensile strength approximately 70,000 lb.; elongation 25 per cent; carbon .25 to .30; manganese .60; silicon .25 to .30 per cent. All strains are removed from the castings by annealing.

In the steel trap, the same basic operating principles are used as are incorporated in the standard Armstrong trap. As in the standard trap, the discharge is at the top so that oil and sediment are forced out whenever the trap discharges. An air port in the closed end of the inverted

STEEL BODIES ARE USED FOR HIGH PRESSURE SERVICE

submerged bucket permits any air that may enter the trap to rise to the top and be released when the trap discharges.

Realizing the severe service conditions imposed by high pressure and superheat, the valve parts have been made particularly rugged, and throughout the trap is designed to stand up under severe conditions. The valve parts are non-corrosive chrome steel, machined from bar stock, then heat treated. The valves are furnished with orifices suitable for pressure up to 500 and 600 lb., or higher in special cases. The cap is bolted to the body with eight to ten large bolts, depending on the size of the trap.

After the trap is completed, it is hydraulically tested to pressures up to 3,000 lb., to insure tightness of castings, joints, and valves. The steel body trap is also made for pulsating pressure service.

CO-OPERATION AGREEMENT has been made between the Department of the Interior and C. A. Hirshfield of Detroit, representing a group of large central power plant operators, to make a survey of present conditions relating to the use of power plant refractories. The survey will be conducted by engineers of the Bureau of Mines. With the present high ratings at which boiler plants are being operated and the increasing use of pulverized coal with its attending high temperatures, the refractories now available for lining boiler furnaces are proving inadequate. In this survey a study is being made of the characteristics of refractories now available for use in power-plant boiler furnaces, and the conditions under which they are used, their life in operating practice under the conditions prevailing at different plants and the way in which the refractories now marketed fail to meet these conditions. The purpose of the survey is to obtain fundamental data to be used in bettering refractory service.

Code of Standard Practice for Steel Construction

DURING THE 35 yr. that have elapsed since structural steel was introduced, there has developed an industry engaged in the fabrication and erection of this material which is now furnishing more than $300,000,000 worth of products to the public annually. The development of this enormous industry has brought into existence many inconsistent practices and definitions.

To clear up this confusion and eliminate the various sources of dispute, the American Institute of Steel Construction, representing the industry between the rolling mills and the buying public, has undertaken the codifying of the various trade practises, with a view of establishing uniform procedure.

One instance of the many fruitful sources of misunderstanding between buyer and seller is furnished by the classification of the various iron and steel items entering into a structure. In the past there has existed a great deal of confusion as to just what constitutes structural steel and iron. The Institute's Code of Standard Practice has divided the steel entering into a structure into the following classes:

Class "A"—Structural Steel and Iron
Class "B"—Ornamental Steel and Iron
Class "C"—Steel Floor Joists
Class "D"—Miscellaneous Steel and Iron

Under these four classifications the various items are enumerated in sufficient detail to eliminate any possibility of doubt as to the material to be delivered under contract.

Throughout the code every possible effort has been made to safeguard the interests of the buyer equally with those of the seller. The result is a code which defines in unmistakable terms the rights of all parties concerned, with a resulting economy to the user and producer of structural steel in its various forms.

This report clears up definitely the basis of invoice weights. It defines what constitutes a plumb building, something which has never been done before. On the question of delays, rigid requirements have been set up which tie the hands of the seller equally with those of the buyer in every detail thus making the question of compensation and adjustments for such delays simple, definite and free from obscurity or the countless loopholes that have been the source of so much annoyance to the industry and the users of structural steel.

In connection with the code, the Institute has worked out a standard form of proposal, under which the seller agrees to furnish to the buyer certain materials and labor, "in accordance with the conditions of the Code of Standard Practice of the American Institute of Steel Construction." Execution of this proposal by buyer and seller is all that is necessary to make the code operative on any contract.

GROUP PLAN insurance for its employes, 250 in number, has been acquired by the Gardner Governor Co. of Quincy, Ill. The company and the employes jointly pay the premium which is for a total coverage of $250,000. This insurance pays for total disability up to 60 yr. of age as well as at death, also provides health and accident insurance of $10 a week up to 26 weeks. As additional service is a distribution of monographs on the care of the health and a free visiting nurse service available in case of sickness or accident and to supervise during convalescence.

News Notes

National Association of Practical Refrigerating Engineers held one of its most successful conventions in New Orleans, November 11, 12, 13 and 14, 1924. This was the Fifteenth Annual Convention and Exhibition of this Association. In the matter of attendance, all previous records were broken, as a total of 908 were registered at this convention. The following officers were elected for the N. A. P. R. E.: President, Erle Ormsby, St. Louis, Mo.; First Vice-President, B. S. T. Dobree, New Orleans, La.; Second Vice-President, Fred I. McCandlish, Kansas City, Mo.; Secretary, Edw. H. Fox, Chicago, Ill.; Treasurer, Charles W. Chapman, Detroit, Mich.; Sergeant-at-Arms, John Roth, Emporia, Kans.

F. D. Harger, mechanical engineer for many years connected with the Mono Corporation of America and more recently with the C. J. Tagliabue Mfg. Co., Brooklyn, has accepted a position as sales manager and supervising engineer with the Eastern Division of the Perolin Co. of America, 342 Madison Ave., New York City.

Emanuel Co., of New York, N. Y., has recently bought the power plants at Eureka Springs and Harrison, Ark. The company is planning on the installation of a new 300-hp. Fairbanks-Morse oil engine, in the old power and light plant at Eureka Springs and running a high tension line to Harrison. G. B. Fuller is the chief engineer at Eureka Springs.

John Lyell Harper, vice-president and chief engineer of the Niagara Falls Power Co., died on November 28 at the Memorial Hospital, Niagara Falls, N. Y., following an operation for appendicitis.

In 1902, after a period of general engineering work, Mr. Harper joined the Niagara Falls Hydraulic Power & Manufacturing Co. as assistant to the engineer, becoming chief engineer in 1904. In 1918, when the company was reorganized, he was promoted to the position he held at his death. He also carried on extensive electro-chemical research work, was vice-president of Harper-Taylor Co., consulting engineers, and was a member of the A. S. M. E., A. I. E. E., A. S. C. E. and other national engineering societies.

Mr. Harper's foresight, initiative and engineering skill have been instrumental in developing the water power of Niagara to its present usefulness. Here, as in a great experimental laboratory, he has been largely responsible for that pioneer work in the generation and transmission of hydroelectric power that has contributed so much to the engineering profession, and that will stand as a monument to his genius.

City of Seattle has applied for a preliminary permit for an installation on the upper Skagit River and its tributaries in Whatcom County, Washington. The city proposes to construct a gravity-section concrete dam about 400 ft. high, 1000 ft. long at the crest and 50 ft. long at the base, in the Skagit River about a mile below the mouth of Ruby Creek, creating a storage reservoir with area of 8000 acres and capacity of 1,000,000 acre ft. The waters of Thunder Creek are to be diverted into the reservoir by means of a diversion dam 2½ mi. above the mouth of the creek with a tunnel 3¼ mi. long. A pressure tunnel 3¼ mi. long will deliver the water to a power house to be located near the mouth of Seattle, the waters from which will also be diverted through the power house by means of a diversion dam with a conduit 3¼ mi. long. The power capacity of the proposed installation is about 300,000 hp., intended for public-utility purposes.

Narragansett Lighting Co. has recently placed an order with the General Electric Co. for a 35,000-kw. turbine generator set with direct connected exciter.

Northwestern Electric Co., Portland, Ore., is now enlarging the Lincoln station at Portland by installing two Stirling Boilers of 1000 hp., each to be operated at 250 lb. pressure and 125 deg. superheat. This addition will bring the boiler capacity of the Lincoln station to 6000 hp. The furnaces are equipped for the burning of both hog fuel and fuel oil. O. L. Lefever is General Superintendent, A. D. Leach is Superintendent Steam Distribution and Tom Perry is Superintendent of Portland stations of the Northwestern Electric Co.

Louisiana Pulp & Paper Co., Bastrop, La., recently started the construction of one of the largest and most modern plants of its kind in the South. The plant will be operated by electricity throughout, the equipment all being 440 v. 60-cycle and the total connected load will be 6590 hp. Two 450-hp. Terry turbines, are to be installed and five 825-hp. type K Casey-Hedges boilers. Three boilers are being installed now and the two additional boilers will be added as soon as possible. Natural gas will be used for fuel. Jack Friend, consulting engineer, is in charge of the installation. The plant will be completed and in operation by September, 1925.

Wisconsin Land & Lumber Co., of Hermansville, Mich., is installing in its Hardwood Flooring Mine Plant, five horizontal return tubular boilers, furnished by the Tudor Boiler Works of Cincinnati, Ohio. These boilers are 150 hp. and will operate at 150 lb. steam pressure. They will be equipped with Quinn flat arch furnaces and flat rear arches, Quinn Soot Blowers and Dravo superheaters. Additional equipment being installed new at this time consists of a Brady steam jet ash conveyor system and Link Belt fuel conveyor. The old engines were taken out and replaced by one new Filer and Stowell, 750-hp. Corliss. Grinnell piping was used throughout with Lunkenheimer valves and fittings. The installation was designed and placed under the direction of the company Plant Superintendent, D. J. Murray.

Books and Catalogs

Charles Proteus Steinmetz. By J. W. Hammond; 8 vo., 482 pages, illustrated, cloth; New York, N. Y., 1924. Price, $4.00.

This is the life history of the most remarkable and outstanding figure in the entire realm of electrical engineering and is a work which no electrical engineer should fail to read. Without question it is one of the most interesting biographies we have ever read.

Steinmetz! What marvels, what intellectual achievements the very name conjures to one's mind. Who in even the remotest way connected with the electrical industry fails to recognize the power the name implies?

Coming here at the age of twenty-four, a refugee from political persecution, penniless, unable to speak the language, handicapped by physical peculiarities amounting to deformity, he became the greatest electrical engineer of all time. It is therefore not to be wondered at that the story of this man's life and his accomplishments should be intensely interesting. His achievements, however, tell only

one phase of Steinmetz's life, and the book holds a delightful surprise in its revelation of the human side of his character.

Born in Poland, we see him first in his home, a willful, spoiled, solitary child who, when he was first taken to school, had difficulty in learning the multiplication tables. Indeed so toilsome did his progress seem that his teachers began to regard him as a dull pupil. Later we find him, a student at the University of Breslau, where his brilliant intellect first made itself manifest. He had not been at the University long before he attracted the attention of his professors because of his intense zeal for assimilating knowledge. This part of his life is particularly interesting since it was during this period that he first pledged his allegiance to the socialistic ideals which remained with him throughout his life; also because it was during this time that he first began to interest himself in the great subject of electricity. Little had been done in electricity at that time and even Steinmetz did not realize that the subject of electrical science was to concern him more closely throughout his life than any other thing.

Even at this time there were characteristics about electricity that vividly appealed to young Steinmetz. To him the little that already had been accomplished in electricity foreshadowed in some degree the effect that such a manifestation of boundless energy would have upon mankind. Furthermore, the mathematical possibilities of the new science appealed to him. So, Steinmetz took up electrical engineering.

In the six years of diligent activity at the University of Breslau, we see young Steinmetz emerge from the quiet grind of his first semester to become the center of a risky determined student political movement which ultimately was the indirect cause of his coming to America.

His career in America, one of steady progress and achievement, culminated in his employment in 1893 by the General Electric Co. His progress with the General Electric Co. was contemporary with the progress of that company itself. No one can think of the achievement of the General Electric Co. without thinking of that strange, misshapen genius, Chas. P. Steinmetz, whose every word was law and gospel in a G. E. building—a man to whom no regular salary was paid. His living needs were small and modest and the General Electric Co. simply gave him "carte blanche" to draw upon them for money as he wanted it.

This book is the authorized biography of Steinmetz. Too busy to write an account of his own life, Steinmetz finally decided that Mr. Hammond should be his biographer, and supplied him with many of the facts on which the book is written. Before his death, Steinmetz had read and approved some of the chapters contained in this volume.

The author has told an intimate and interesting story which will be of interest not only to engineers but to the general public also.

POWER PLANT MACHINERY, Vol. II, by Walter H. James and Myron W. Dole; 267 pages, 250 illustrations, size 6 by 9 in., second edition, New York, 1924. Cloth, $3.00 net.

In the revised edition of Vol. II of Power Plant Machinery, the authors have written a text that will be of considerable value to the industrial executive or the power plant engineer, as well as to the engineering student, for whom it was especially written.

Part I takes up first the general construction details and fundamental principles of operation of the unaflow, the Prosser and the locomobile types of steam engines, and several types of steam turbines. Some interesting data on air compressor construction are followed by a section devoted to reciprocating and centrifugal pumps, a chapter on power steering and reversing mechanisms used in marine work, and a chapter on the steam hammer, the rock drill and the hydraulic press.

In Part II appear construction details of boiler feedwater heaters, economizers and various boiler auxiliaries, with a chapter on condensers.

PULVERIZED FUEL, COLLOIDAL FUEL, FUEL ECONOMY AND SMOKELESS COMBUSTION, by Leonard C. Harvey; 492 pages, 246 illustrations, size 7 by 10 in., first edition, New York, 1924.

This volume is one which thoroughly covers the subjects listed in its title both from the viewpoint of European and American practice; in fact, though written in England, a great portion of the text matter and many of the illustrations are drawn from American practice after a personal investigation by the author.

From time to time arguments have been raised against the use of pulverized fuel. Careful analysis is made of such subjects as: spontaneous combustion, explosion, storage difficulties, transportation, reabsorption of moisture, preparation costs and capital expenditure. The question of the various grades of fuel suitable for use in pulverized form is discussed in Chapter IV. Information is given on the suitability of weathered coal, inferior coal, dust, coke, peat and lignite as well as on the solid fuels of a higher grade.

Notes on combustion with special reference to pulverized coal are unusually comprehensive. Flame temperature, refractories, combustion chamber design, combustion and the nature of ash in fuel are considered as well as calculations for furnace efficiency and for the amount of air necessary for the combustion of fuel.

Coal washing is a subject which is comparatively new. This volume takes up the subject from the general viewpoint of comparing the various coal washing methods. The use of colloidal fuel for locomotive and marine purposes is discussed and experiments, with the use of this fuel on the Great Central Railway, are outlined. Low temperature carbonization of coal is treated briefly from the standpoints of recovery of byproducts, distillation of brown coal and a description of one of the more important processes.

Complete outline is given of plants for the production of pulverized fuel, this covering such subjects as general outlay arrangements, buildings and masonry and the drying of coal. The importance of fineness and moisture content are also given consideration as are also the types of pulverizer mills, the cost of installation and production of pulverized coal. The application of pulverized coal to steam boilers is treated in a thorough manner. The appendix gives a great amount of combustion data, a list of installations and a bibliography of European and American articles in publications dating from 1879 to 1923.

Taken as a whole, this volume is a comprehensive and authoritative compilation of information on subjects of great importance at the present time.

MESTA UNA-FLOW ENGINES are covered in a folder which has been issued by the Mesta Machine Co., of Pittsburgh, Pa.

THE NORTHWESTERN BOILER DAMPER CONTROL for use with underfeed stokers using forced draft or with gas or oil fired boilers is covered in a bulletin issued by the Northwestern Manufacturing Co., Milwaukee, Wis.

KEELER DOUBLE DUTY BOILERS are described in a new bulletin published by the E. Keeler Co., Williamsport, Pa. The claims for this boiler are that it is highly efficient although it does not require an expensive masonry setting. It is designed for either power or heating service, hence the name.

EARLE CENTRIFUGAL PUMPS are described in a bulletin issued by The Earle Gear and Machine Company, Wayne Jct., Philadelphia, Pa. In addition to describing and illustrating the line of pumps the bulletin also gives some curves and alinement charts which are for use in figuring pumping installations.

MAJOR PRODUCTS of the Combustion Engineering Corporation of New York City are covered in a bulletin which has recently been issued by that organization. The bulletin is a reprint of pages from the A. S. M. E. condensed catalog of mechanical equipment and covers briefly the apparatus which is manufactured.

CONVEYORS CORPORATION OF AMERICA, 326 West Madison St., Chicago, Ill., has just issued an 8-page bulletin, describing the American high duty conveyor. This conveyor is designed to handle ashes and cinders from large power plants and accordingly its tonnage capacity per hour is unusually high. It is built with a 9 in. conduit through which the ashes pass.

L. J. WING MFG. CO. has issued a new edition of a bulletin describing Type E M motor driven variable speed blowers for forced draft. These units while having a general application for all boilers have been especially developed for low pressure heating boilers. The bulletin has a number of new illustrations showing how these blowers are installed with heating boilers of various types.

BULLETIN NO. 48,941A, entitled "CR-9006 Enameled Resistor Units," has been issued by the General Electric Co. This is a well-illustrated booklet describing the uses and advantages of these units and giving standard ratings and dimensions. Applications are given for several different fields of service. The bulletin contains 18 reading pages.

DETRICK ARCHES is the title of a 50-page bulletin which has been published by M. H. Detrick Co., 140 So. Dearborn St., Chicago. The bulletin shows the application of Detrick Arches for many types of furnace and it also shows the details of the hollow side wall construction which is used with pulverized furnaces. Part of the bulletin also takes up the application of such arches in industrial furnace work.

STEAM CONDENSERS are covered in a 44-page bulletin which is now being distributed by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. In addition to describing the line of surface, low-level, jet and barometric condensers built by this organization, the bulletin also presents some interesting technical information on the subject. Curves are used to show the effect of cleanliness on the rate of heat transfer through surface condenser tubes. In conducting the tests, special arrangements were made to segregate the flow of cooling water through one of the tubes in a 25,000-sq. ft. surface condenser. The quantity of cooling water was regulated and measured by weighing. The curves show quite clearly the effectiveness of different methods of cleaning. The conclusion is drawn that condensers designed on the basis of heat transfer rates obtainable on new clean tubes must be cleaned frequently in order to maintain satisfactory performance. An additional conclusion is that condensers should be designed on the basis of a nominal heat transfer rate rather than a high one. Some information is also given as to how to proceed to check the performance of a condenser while it is in operation, including equations and curves which are to be used. One section also covers removal apparatus and curves show the weight of the mixture of air and water vapor that must be removed from a condenser in removing one pound of free, dry, air.

A NEW CATALOG COVERING McKim gaskets has just been issued by the McCord Radiator & Mfg. Co., Detroit. This catalog covers gaskets of various metals—copper for general use, steam, water, air and internal combustion engines; aluminum for acid; steel for boiler handholes, tin, zinc and monel for particular chemical conditions.

TRANSMISSION is the title of Catalog No. 31, which is an 80-page publication, now being distributed by the W. A. Jones Foundry and Machine Co., 4401 West Roosevelt Rd., Chicago. The catalog describes the various types of drop hangers, pillow blocks, wall brackets, base plates, flange couplings, flexible couplings, belt tighteners and other devices which are made by this organization.

FLOOR OPERATED ELECTRIC HOISTS is the title of the 60-page bulletin issued by the Shepard Electric Crane and Hoist Co., of Montour Falls, New York. It described each type of floor operated hoist made by this organization, shows various installation views and gives clearance, drawings and dimensions and complete information regarding capacity, heights of lift, prices, etc.

CURTIS STEAM TURBINES FOR MECHANICAL DRIVE is the subject of Bulletin No. 42,019 A, now being distributed by the General Electric Co., of Schenectady, New York. This turbine is especially adapted to driving circulating and boiler feed pumps, fans, blowers and other such apparatus. The bulletin goes into construction features of these machines and also illustrates various applications which have been made.

"STREET LIGHTING TRANSFORMERS," bulletin No. 45124 is a new 32-page publication of the General Electric Co., Schenectady, N. Y. In it are described various types of General Electric constant current transformers, both indoor and outdoor and for pole or subway mounting, individual lamp series transformers, cutouts, transformer controls and protective devices. A table of transformer capacities is also included.

THE HELL GATE TESTS AND THEIR SIGNIFICANCE is the title of a bulletin recently published by the American Engineering Co. of Philadelphia. Considerable experimenting has been under way at the Hell Gate Station with water heating surface built into the walls of the boiler furnaces. The results of these tests are summarized in this bulletin. An overall efficiency of 92.7 per cent was obtained on a 28-hr. run and a boiler rating of 528 per cent was maintained on a ¾-hr. test run. The part which the Taylor Stoker played in securing this unusual performance record is also discussed.

Universal Brotherhood *and* Permanent Peace

> **"First: That we declare it our firm conviction that war as a method of adjusting international misunderstandings is the supreme peril of humanity and that we affirm the leaders of the nations of the world ought now to be called upon to promptly take such steps as will guarantee the security of the people against the return of the use of aggressive force. We condemn war as the enemy of human progress and futile as a means of adjusting disputes among the nations.**
>
> **"Second: That we pledge our utmost endeavor to awaken a more intense public sentiment against all those insidious movements which have a tendency to arouse war passions and to favor all proper efforts which are working to accomplish universal enduring world brotherhood and peace."**

EVER SINCE man became man he has noted the lengthening of the days at this season, and instinctively raising his face to the sun he has looked forward to a new year, the rejuvenescence of the earth, and another cycle of the food-growing seasons.

In this season of incipient promise have centered the conceptions of brotherhood and peace, a yearning which is found in all peoples.

At this time it is well to think of what practical measures may be taken to promote this undoubted desire for permanent peace.

Last summer the representatives of organized advertising throughout the world adopted a resolution that is printed in part at the head of this article.

No one can know the futility of war as a means of settling differences better than advertising men. First hand experience has proved that only better understanding will sell goods, create good will, build business and permanently improve the condition of a people.

No one can know the wastefulness of war better than an engineer. He knows the limits of the world's resources; he sees humanity's great needs, and can calculate the tremendous burdens that might be lifted from mankind with the energy equivalent to that expended in a single battle.

Differences will always rise between men and organizations of men. In the business world there is an eternal rivalry, keen as any between nations.

As long as men are men, this struggle and rivalry will go on. It is the very actuating force of progress, the driving power of civilization. Without it the human race would degenerate into the condition of their ancestors.

In industry and commerce there have been created voluntary courts of arbitration. Standards of practice, codes and regulations have been established and trade associations formed to put them in force.

Nowhere has this movement gone farther than in the power plant field and the field of advertising, to each of which POWER PLANT ENGINEERING belongs.

In the years this magazine has been published we have seen unbridled competition, secret rebates, misrepresentation of facts, and scores of other destructive trade practices done away with.

We have seen the growth and development of constructive forces, of confidence, of better understanding among competing manufacturers, power plants, engineers and associations, just as we have seen similar development among rival publications, advertising men and their associations.

Economic law is the final arbiter. Work against it, and even the winner is bound to lose. Work in harmony with it, and even the loser is certain to benefit.

Better understanding is the fundamental basis for profit, peace and plenty. Advertising is bringing it about between buyer and seller, between competitors—why can not advertising be used to promote this better understanding between peoples and nations?

Anything that is of basic economic service, or can be made so, can be successfully advertised.

Dig down to the causative factors of wars, and economic rivalry is at the bottom. Short-sighted men, men with more passion than brains, see war as the only method of breaking through to more prosperous fields.

Any good engineer or advertising man could show the princes and politicians of any nation scores of ways to give their people greater benefits than could possibly be won by war.

All the wealth of countries that the most successful war might conquer would not compare with the wealth that could be saved and created by improvements in generation and use of power, in marketing products and services, in transportation, industrial processes, agriculture, sanitary works, municipal engineering and in every other activity.

A generation or so ago public utilities, railroads, and businesses, large and small, conquered by force. Trade wars wrecked properties, wasted millions, carried men down to unhonored graves, and alienated the public on which they levied for the means to carry on their wars.

Today better understanding has revolutionized this practice. Great central stations are built by the people, for the people and of the people.

Throughout the entire commercial structure, better understanding is saving time, raising the standards of living, creating new wealth, stabilizing finance and employment and lopping off waste by the millions of dollars yearly.

And now the era dawns when better understanding is bursting through the boundaries of nations, the bonds of different languages, the prejudices of divergent races—a movement that will ultimately bring permanent peace on earth.

Here is a simple trade incident that points the way. Advertising of an American food product had created a demand among the people of a foreign country who could not produce it and had not heretofore extensively eaten it.

A shortsighted legislature, seeing the money going out of that country for this American product, put a tax on it.

But the advertising had done its work so well that the housewives in that foreign country brought about the repeal of that tax.

There were no diplomatic representations, threats between governments or mobilization of armies. Yet wars have been caused by less than this trade incident.

POWER PLANT ENGINEERING endorses the resolution printed above. It will continue to use every means in its power to bring about better understanding to the end that ALL people shall have a better place in the sun.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS.
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis, Ind.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago, Ill.
Detrick Co., M. H., Chicago.
Girtanner Engineering Corp., New York, N. Y.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Jointless Fire Brick Co., Chicago.
Liptak Fire-Brick Arch Co., Chicago, Ill.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc. N. Y

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago, Ill.
Girtanner Engineering Corp., New York, N. Y.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH CONVEYING SYSTEMS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago, Ill.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engineering Corp., New York, N. Y.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
United Conveyors Corp., Chicago, Ill.

ASH TANKS.
United Conveyors Corp., Chicago, Ill.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany, N. Y.

BELTING.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BELT LACING.
Bristol Co., The, Waterbury, Conn.

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Sturtevant Co., B. F., Boston, Mass.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED-DRAFT.
McClave-Brooks Co., Scranton, Pa.

BLOWERS, STEAM.
McClave-Brooks Co., Scranton.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Diamond Power Specialty Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N. Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
Quigley Furnace Specialties Co., Inc., N. Y.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CLEANERS.
Bayer Co., The, St. Louis, Mo.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
Maphite Sales Corp., The, Chicago, Ill.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER COVERING.
Quigley Furnace Specialties Co., Inc., N. Y.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McClave-Brooks Co., Scranton, Pa.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Obermayer Co., The S., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Ref. Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., N. Y.
Webster, Howard J., Philadelphia, Pa

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Page Water-Tube Boiler Co., Chicago, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw, Mich

BOILER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOOKS AND SCHOOLS.
Hays Institute, The, Chicago, Ill.
McGraw-Hill Book Co., Inc., New York, N. Y.
Sweet's Catalogue Service, Inc., New York, N. Y.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis Mo.

BUCKET ELEVATORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Company, Chicago.
Webster Mfg. Co. The, Chicago.

BUCKETS, CLAMSHELL.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Girtanner Engineering Corp., New York, N. Y.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry, Inc., Troy, N. Y.

CEMENT, FURNACE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Obermayer Co., The S., Chicago, Ill.
Quigley Furnace Specialties Co., Inc., N. Y.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford. Mass.

CHIMNEYS.
American Chimney Corp., N. Y.

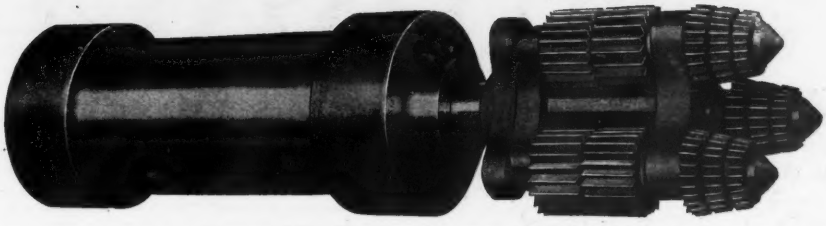
CLEANERS, BOILER TUBE.
Chesterton Co., A. W., Boston, Mass.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago, Ill.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Co., Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens - Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

COAL AND ASH HOPPERS.
Frederick Iron & Steel Co., Frederick, Md.

LIBERTY



Victor "OF" Cleaner with "SF" cutting head

More than a match for your worst scale condition

The Liberty Victor Cleaner has long been known for its ability to get results under difficult scale conditions. With the new Type "SF" long surface cutting head it goes one step further. For the Type "SF" head is about the sturdiest cutting tool yet produced. It combines the utmost simplicity of construction with rugged construction and large cutting surface.

The cutters on the cutter pins are free to move out a quarter of an inch under centrifugal force. No arms, no arm pins are used. There is nothing to wear but the cutters and pins. The head is taken apart when it is unscrewed from the Cleaner shaft.

"Spare the Cleaner and spoil the Boiler"

Try out this combination on your worst scale condition.

Liberty Manufacturing Company
443 Grant Street, Pittsburgh, Pa.

Z-987

CLEANERS

Now CROSS MARKED

for convenience and economy

Service Sheet is the only sheet packing most plants need. This saves money by cutting down your stock room investment. Service Sheet also saves money in the plant because it can be used thinner than other packings with even greater reliability. It is one of the "Standard Seven" Johns-Manville Packings.

Service Sheet Packing

NOW more economical than ever — as the thousands of plants using it will find.

Lines spaced one inch apart are now ruled lengthwise and crosswise on every sheet, covering it with one-inch squares.

By following these lines and counting squares, a piece of sheet can be cut to practically any dimension without a rule. Straight, accurate cutting is easy, preventing waste due to crooked or jagged edges. Center points are easily established and a number of gaskets can be quickly laid out on a sheet so as to get the maximum number of gaskets with the minimum of scrap.

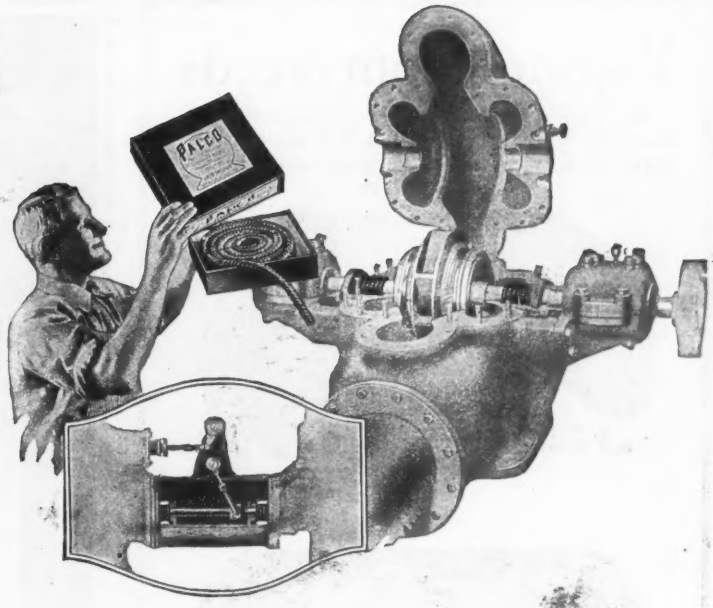
This saves time and money on the cutting bench, in addition to the other Service Sheet economies in the stock room and plant.

JOHNS-MANVILLE Inc.
292 Madison Avenue at 41st Street, New York City
Branches in 62 Large Cities
For Canada: CANADIAN JOHNS-MANVILLE CO., Ltd., Toronto

Through Asbestos and its allied products
INSULATION
BRAKE LININGS
ROOFINGS
PACKINGS
CEMENTS
FIRE PREVENTION PRODUCTS

JOHNS-MANVILLE
Power Plant Materials

Don't Overlook the Need of Lubricant on a Fast Moving Pump Shaft



The centrifugal pump, because of its rotary movement and high speed, demands a packing that remains soft and supplies lubricant in sufficient quantities to keep the rod from wearing.

SQUARE PALCO PLAITED PACKING

has graphite grease lubricant forced hot under pressure into each single strand before plaiting, which keeps the rod in such a state of perfect lubrication as to prevent the wearing tendency of a shaft in a centrifugal pump.

The Cost of Truing Up a Pump Shaft Makes the Packing Very Expensive

If you are having trouble with the packing in your centrifugal pumps, let us send you a working sample of "Palco" to test under your own conditions—state size of packing you use—**sample is free.**

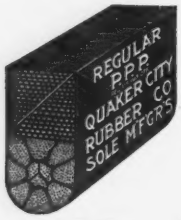
GREENE, TWEED & CO.

Sole Manufacturers

109 Duane St. New York

Engine Room Needs

Regardless of your rubber requirements we have the right products that will fill the bill; give you service, and at very attractive prices.



P. P. P. Rod Packing

EBONITE Sheet Packing

WATER HOSE

PUMP VALVES

RUBBER BELT

When in need of rubber goods specify QUAKER products.

Quaker City Rubber Co.

Manufacturers of

Mechanical Rubber Goods
Auto Tires and Tubes

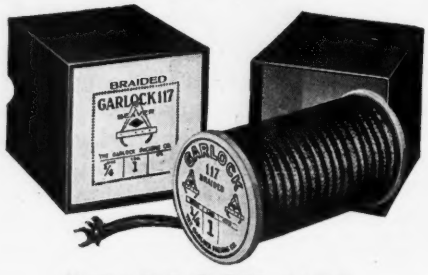
Wissinoming, Philadelphia, Pa.

Chicago Pittsburgh New York

A COMPLETE SERVICE IN
"John Crane"
FLEXIBLE METALLIC PACKING
"GOOD RESULTS"
Centrifugal Pumps
"'JOHN CRANE' Packing Style 100 has been in operation for five years on my 100 hp. steam turbine driven pump, 3000 r.p.m., operating against 300 lb. water pressure."
Get these good results on your centrifugals. Order Style 100 (illustrated)—sizes ⅛ in. to 1 in., spirals 10 ft.
Crane Packing Company
1802 Cuyler Avenue, Chicago
706 Dodge Building, New York
Distributors in principal cities.

GARLOCK

VALVE STEM PACKING SERVICE



"GARLOCK-117"

A valve stem packing built for service from the "Crude to the Finished Product" in our factories.
Manufactured from long fibre Asbestos and thoroughly lubricated with the celebrated Garlock Lubricant.
It is a part of Garlock Packing Service which means guaranteed satisfaction.

The Garlock Packing Company

Manufacturers of
Asbestos Rubber GARLOCK PACKINGS Metal Fibrous

Gen'l Offices and Factories, Palmyra, N. Y.
Canadian General Office and Factory, Hamilton, Ont.
Sales Offices and Warehouses in all Industrial Centers

The Standard Packing of the World

He is NOT sawing out a "Flexitallic" Gasket

Avoid Expensive Gasket Removal

Under certain conditions some engineers recommend the removal of adhering gaskets by SAWING them out with a hack saw.

Sawing is probably as good a way as any, and better than most methods. IF the gasket "sticks"—BUT—why was the sticking kind used in the first place? Why, when "Flexitallic" Gaskets have been on the market for over 12 years?

You can be certain that the engineer in the above photograph is NOT sawing out a "Flexitallic" Gasket because they NEVER stick. They are very easy to remove. Simply loosen the joint, take out half of the bolts, and you can slip the "Flexitallic" out—all in a few moments' time.

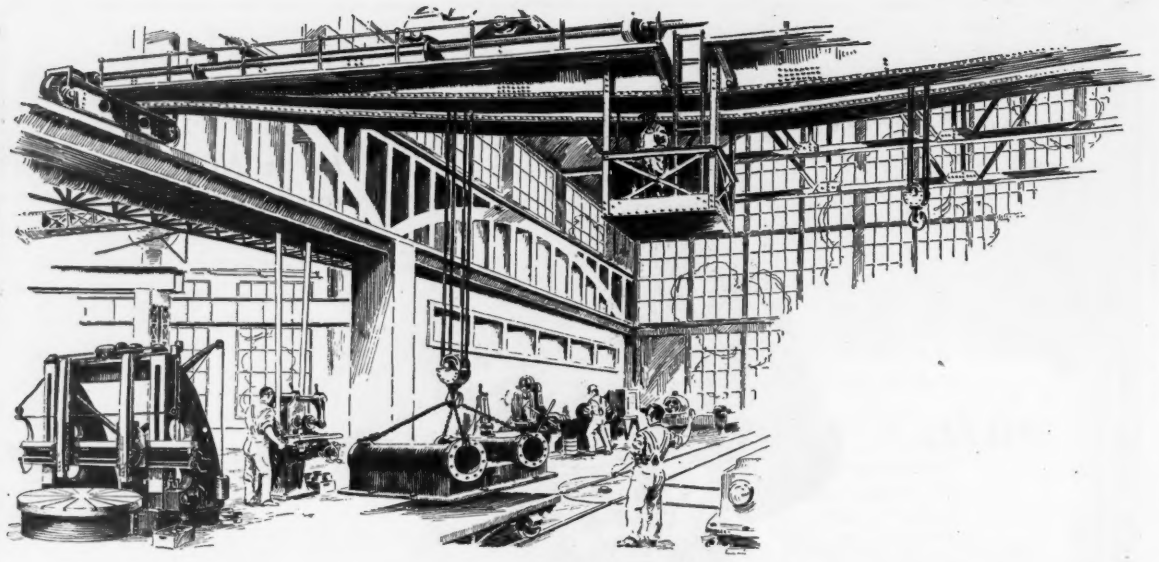
Moreover, to saw out a "Flexitallic" Gasket would be a very tedious job indeed because these gaskets are made of steel and asbestos. There are 16 layers of steel per inch, with asbestos wound between every layer. The cross-sectional view in this advertisement shows clearly how the gasket is constructed.

Easy removal, however, is only ONE of the valuable "Flexitallic" features. It is the ONLY gasket that is applicable to boiler handholes and manholes as well as to pipe flanges. It is just as easily inserted as removed. And the joint is much more easily made leakless. You MUST NOT screw a "Flexitallic" tight. You MUST NOT use a long-handled wrench. Just turn the nuts on with the fingers, give them a little additional pressure by means of a short wrench, and you will find that the joint is already made leakless. Best of all, the joint remains flexible. To screw the bolts tight with a "Flexitallic" in it will make the joint as non-flexible and unyielding as with any other gasket —a practice that we do NOT recommend.

To prove to you that this gasket will do what we claim for it we suggest that you put one in your WORST joint. We will send you a "Flexitallic" free. Give us the details, namely, the inside diameter of the bolt ring, the inside pipe diameter, and state for what service. If to be used on water tube boilers just state name of boiler and we will know what to send.

"Flexitallic" Gasket Co.

CAMDEN, N. J.



The One Sure Cure for Machinery Troubles

For Wool

Magic Wool Oils

For Textile Machinery

Blanquol Apron Oil
Blanquol Loom Oil
Blanquol Shear Oil
Blanquol Rub Roll Oil

The Tide Water Power Group

Grenol Cylinder Oils
Clarol Machinery Oils
Tycol Bearing Greases
Dynol Engine and Turbine Oils

Machinery troubles and poor lubrication generally go together. Worn bearings, loss of power and expensive shutdowns are nearly always traceable to improperly lubricated bearing surfaces. Here the highest percentage of power loss exists—20 to 30 percent in many cases.

With a horse-power year costing seventy-five dollars and more, it will pay you to study the many out-of-the-way places where friction may be sapping the strength of power.

The one sure cure for this condition is the use of properly refined lubricants, accurately selected for the purpose.

Clarol Machinery Oils, produced under the strict supervision of the Tide Water Engineering Bureau, are especially designed for this severe service. They effectively combat costly friction and show remarkable lasting power, whether exposed to high speeds or heavy pressures, or both.

Make sure you use the right kind of lubricants (such as Clarol Machinery Oils) in the right places (as specified by a Tide Water Lubricating Staff Engineer) and watch your production curves jump!

A Lubricating Staff Engineer will be glad to call and discuss your lubrication problems with you.

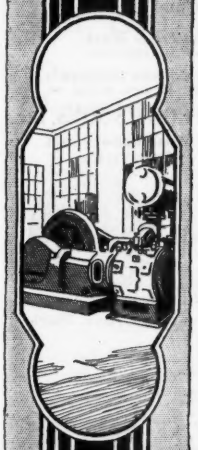
CLAROL

MACHINERY OILS

TIDE WATER OIL SALES CORPORATION

11 BROADWAY, NEW YORK **EAST PROVIDENCE, R. I.**

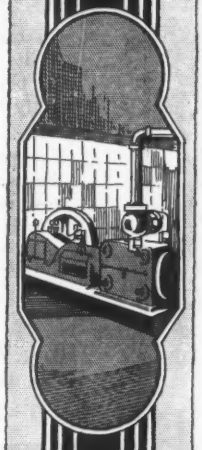
Scientific Lubrication will Cut Your Costs



THE highly specialized machines which industry employs require highly specialized lubricants if they are to function at highest efficiency. This need of special lubricants is encountered at every point throughout the plant. It starts with the lubrication of the prime movers in the power plant, follows along the shafts and drives by which power is transmitted and distributed and ends only in the machines which utilize this power to convert raw materials into finished parts or products.

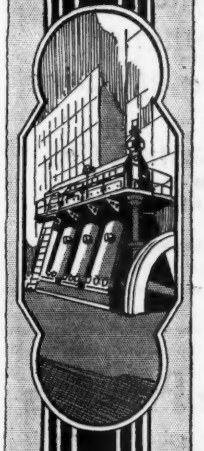
Recognizing the need of quantity production, Industry provided itself with new types of high speed machines. That such machines required special lubricants became apparent immediately. Our engineers therefore made analyses of the operation of machines of every class and description.

They determined the exact qualities and properties a lubricant should possess to lubricate perfectly any particular machine. After establishing these facts, they were able to produce the new lubricants needed, though only after months, and in many cases, years, of research and experimentation. Today, this company is producing a complete line of



Standard Oils and Greases

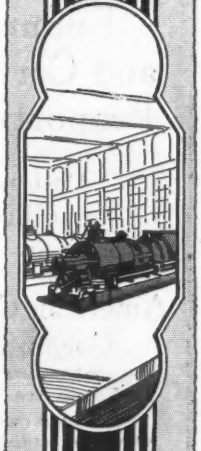
some one of which will exactly meet the lubrication needs of each mechanism. These lubricants are always uniform and each serves perfectly the purpose for which it is produced.



As each lubricant is made for a special purpose, it is of great importance to use them in the proper place and proper manner. To insure their proper use, the company places the services of its lubricating engineers, free of charge, at the disposal of industry throughout our territory.

Upon request, they will visit your plant, make a complete survey of your lubrication system and submit a report on it, together with their recommendations. They will point the way to more efficient lubrication, which means lower operating costs.

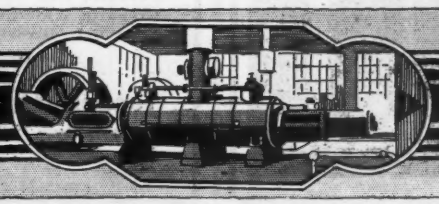
To avail yourself of this service does not obligate you and you are, of course, free to follow their suggestions, or not, as you may see fit. We will welcome an opportunity to render you this service at any time, though preferably now.



STANDARD OIL COMPANY
(INDIANA)

General Offices: 930 S. Michigan Avenue, Chicago, Illinois

ILLINOIS	INDIANA	IOWA	MICHIGAN	WISCONSIN	MISSOURI
Chicago	Evansville	Davenport	Detroit	La Crosse	Kansas City
Decatur	Indianapolis	Des Moines	Grand Rapids	Milwaukee	St. Joseph
Joliet	South Bend	Mason City	Saginaw	MINNESOTA	St. Louis
Peoria	KANSAS	Sioux City	N. DAKOTA	Duluth	
Quincy	Wichita	S. DAKOTA	Fargo	Minneapolis	
		Huron	Minot		



HARRIS
TRADE MARK—REG. U.S. PAT. OFF.
OILS AND GREASES

For Best Results

No machinery of any kind can do its work properly and give the best results unless it is perfectly lubricated.

For years, engineers throughout the world have been obtaining best results through the use of Harris Oils.

"America's Leading Lubricants"

Trade Mark Reg. U. S. Pat. Off.

THE A. W. HARRIS OIL COMPANY
329 So. Water St. Providence, R. I.

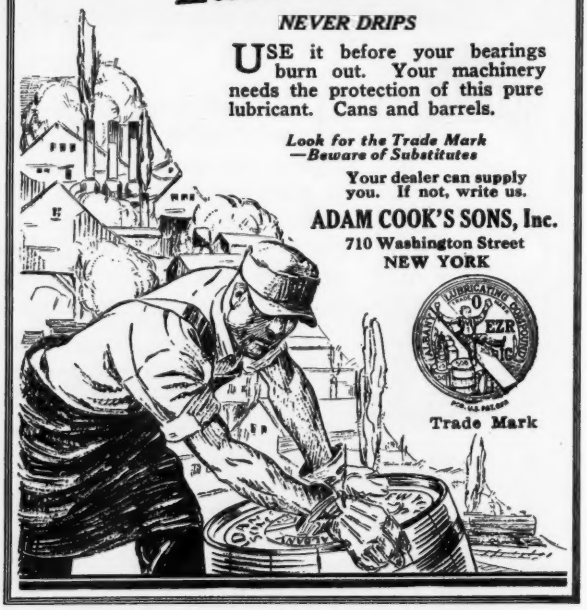
Be Firm—DEMAND
ALBANY GREASE
THE 100%
Lubricant
NEVER DRIPS

USE it before your bearings burn out. Your machinery needs the protection of this pure lubricant. Cans and barrels.

Look for the Trade Mark
—Beware of Substitutes

Your dealer can supply you. If not, write us.

ADAM COOK'S SONS, Inc.
710 Washington Street
NEW YORK



Trade Mark

Radial Brick Chimneys

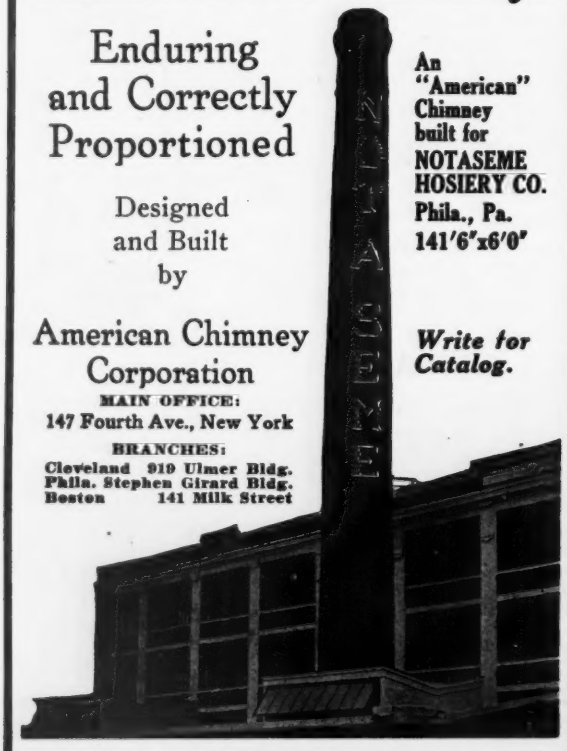
Enduring and Correctly Proportioned

Designed and Built by

American Chimney Corporation

MAIN OFFICE:
147 Fourth Ave., New York

BRANCHES:
Cleveland 910 Ulmer Bldg.
Phila. Stephen Girard Bldg.
Boston 141 Milk Street



An "American" Chimney built for NOTASEME HOSIERY CO. Phila., Pa. 141'6"x6'0"

Write for Catalog.

KEYSTONE GREASE
The Master Lubricant

Makes the most efficient equipment more efficient

The Keystone Lubricating Co.
Executive Office and Works:
21st and Clearfield Sts. PHILADELPHIA, PA.
Established 1884
Agencies in Principal Countries throughout the World

Dixon's Graphite Products

are made of the best and most suitable materials obtainable, compounded after a fashion determined by many years' experience.

Ticonderoga Flake Graphite
Graphite Cup Greases
Graphite Waterproof Grease
Solid Belt Dressing
Boiler Graphite
Graphite Brushes
Graphite Joint Compound
Silica-Graphite Paint

Write for Booklet 96-KP.

Joseph Dixon Crucible Company
Jersey City, New Jersey
Established 1827

OHIO Grease

For the Narrow Gauge Road

There is no better nor more economical lubricant than Ohio Journal Grease. It is extensively used on the narrow gauge equipment about saw mills, steel mills, cement plants, etc. Particularly adapted for use with wool waste in all journal boxes or we can mix it for you.

We shall be pleased to send you samples.

The Ohio Grease Co. Loudonville, O.

HI

If We Can't Save You Money in Your Boiler Room through the

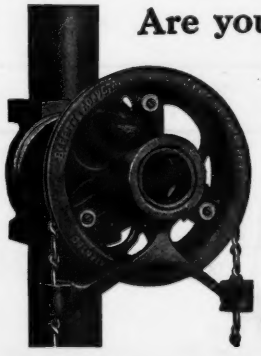
Canady System

of Automatic Furnace Control

we'll tell you so, promptly. If we can save you money through the Canady System, as we have for so many others, we'll do it under a guarantee that will protect you in every way.

Just what are your combustion conditions? It will cost you nothing to consult with us on this subject, which has been our only concern for twenty years.

CANADY ENGINEERING COMPANY
152 West 42nd Street, New York



Are you waiting for someone to break his neck before you put Babbitt Rims on your overhead valves?

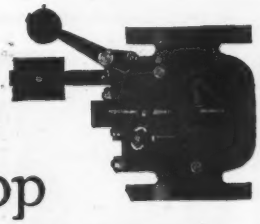
Don't Wait! It's Bound to Happen if You Do!

Don't Delay! Buy Now! Safety First!

Babbitt Steam Specialty Co., Inc.
55 S. Water St.
New Bedford, Mass.

Shuts off steam the instant racing begins

Strong Engine Stop



assures a positive check against Accidents

It operates by centrifugal force and power of gravity. Only two essential parts, the speed limit and the shut-off valve in the steam line to the engine. No belts, chains, gears, electric motors or delicate mechanism to get out of order.

Write for Catalog T-30.

The Strong, Carlisle & Hammond Co.

Manufacturers of a Complete Line of Steam, Vacuum and Radiator Traps, Steam and Oil Separators, High and Low Pressure Reducing Valves, Pump Governors, Engine Stops, Emergency Check Valves, etc.

Cleveland, Ohio

The Standard Armstrong Trap is furnished for pressure from 0 to 300 pounds —for service on vacuum where inlet pressure is greater than outlet pressure —for draining water from compressed air expansion tanks, separators, etc.—for service on grease. The Armstrong Special Trap is furnished for pulsating pressure and unusual conditions.

An air-bound steam trap is worse than none

A TRAP that CAN become air-bound, IS air-bound a good part of the time. The ever-present air in the steam line is a steam trap's worst enemy.

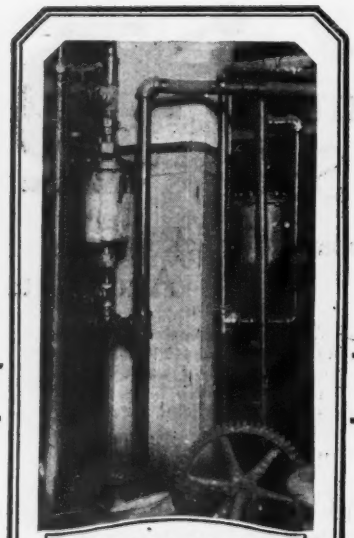
How fully engineers appreciate this, is brought out in their never-ending praise of a steam trap that CAN'T become air-bound—the Armstrong.

Air entering the Armstrong Trap MUST rise to the top through the port in the closed end of the inverted bucket —and it follows that it MUST be forced out when the trap discharges. The top discharge turns the trick—the same thing that produces the famous self-scrubbing action. And top discharge is a result of the inverted submerged bucket principle — that exclusive feature of the Armstrong Trap.

Remember that it's far easier to get rid of an air-bound trap than to get rid of the air that causes the trouble. And don't forget that there is a trap that "CAN'T BECOME AIR-BOUND."

Incidentally it is the same trap that won't score excessively and won't pass steam—the trap that is so simple that it can be sold at a moderate price with no sacrifice in quality.

Hundreds of Armstrong boosters "discovered" it through the ninety-day test. Ask about this exceptional free test offer.



The Armstrong is light and small —ideal for installation in close quarters. Note that the traps illustrated above are two inch traps, yet they are easily supported by the line without special brackets.

ARMSTRONG MACHINE WORKS
310 Steam Saving St., Three Rivers, Mich.

Your jobber will get Armstrong Traps for you

Armstrong Steam Trap

PPE12-15M-RTG

Within the Pages of This Free Bundy Book

Some of Its Contents:

Tables to Determine Trap Rating

Traps for All Services

Traps for All Pressures

Full Descriptions

Many Illustrations

The Bundy Guarantee

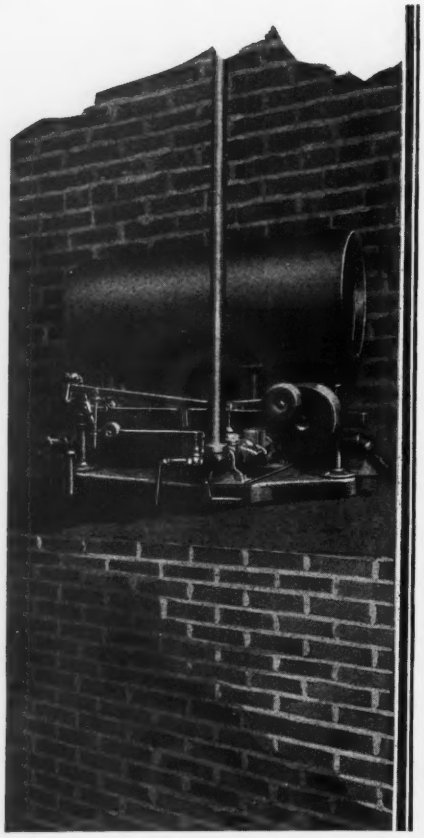
You Will Find the Answer to Your Trapping Problems

Write for free Copy of Bundy Trap Book "E"

BUNDY STEAM TRAP CO., 39 Elm St., Nashua, N. H.

Branch Offices:

Boston	New York	Chicago	Philadelphia	Pittsburgh	Baltimore
224 State St.	26 Cortlandt St.	25 N. Franklin St.	1236 Callowhill St.	710 Park Bldg.	345 No. Calvert St.



Would You Leave Water In Your Carburetor?

Condensation in your steam lines is like water in your carburetor. It reduces efficiency—wastes fuel and causes poor performance. If you had water in your carburetor you would waste no time in draining it out.

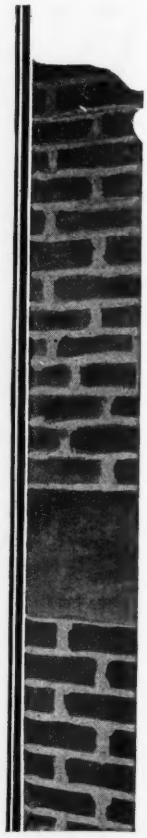
Why not drain the water from your steam lines, separators or heating system with a Morehead Back-to-Boiler System? It will not only keep your steam lines clear and dry, thus enabling every pound of coal to do its maximum work, but also the condensation will be returned to your boilers at high temperature.

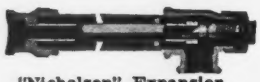
Write and learn how Morehead Back-to-Boiler Systems are effecting big savings in plants throughout the country.

Morehead Manufacturing Company
Dept. P. P., Grand River at Warren
DETROIT, MICHIGAN

127

Morehead
"BACK-TO-BOILER-SYSTEM"
POSITIVELY DRAINS ALL TYPES OF STEAM APPARATUS, DELIVERS CONDENSATION AND FEED WATER TO BOILERS UNDER ALL CONDITIONS AT MAXIMUM TEMPERATURE





"Nicholson" Expansion Steam Trap

THE **Nicholson Line**

Horizontal Combined Separator and Trap

Vertical Trap

Controlling Valve for Steam or Air

Super-Trap Piston Operated

Weight Operated Steam Trap

A steam separator or trap for any service—from high pressure superheated equipment down to low pressure heating jobs. We specialize on condensation problems found in all classes of steam heated industrial appliances (excepting vacuum and return systems). Let us, or one of our district agents, know your troubles and we will recommend and, if desired, furnish one of our devices on trial, to prove we can overcome them.

The Rathbun Co., El Paso, Texas — **W. H. NICHOLSON & CO., 120 Oregon St., Wilkes-Barre, Pa., U. S. A.** — C. M. Thomas, 1512 Broadway, Denver, Colo.

Andrews-Bradshaw Co., B. F. Jones Bldg., Pittsburgh, Pa. — Robert L. Sheraton, 12 Pearl St., Boston, Mass. — S. D. Merton, Pierce Bldg., St. Louis, Mo. — James T. Gordon Co., 50 Church St., New York, N. Y. — Ashmead-Danks Co., 7016 Euclid Ave., Cleveland, Ohio — F. W. Hay & Co., 112 Railway Exchange, Kansas City, Mo. — O. B. McBride, 4933 N. Kedzie Ave., Chicago, Ill. — James M. Jenkins, 417 Jefferson Bldg., Philadelphia, Pa.

McDaniel Steam Trap

For High or Low Pressure

The Trap that holds the Steam and removes all condensation from the steam pipes, steam cylinders, steam coils, jacketed kettles, steam separators, heating coils, and, in fact, at any point where water of condensation will collect. Steam can't blow through, they have large discharge valves and cannot be flooded with sudden flushes of water. Send for our yellow booklet that will tell you more about the Trap, or better still, let us send you one on 30 days' trial and you can see what a steam saver this Trap is. It pays for itself.

Watson & McDaniel Co., 148 N. 7th St., Philadelphia, Pa.

ACE STEAM TRAPS

CORLISS VALVE TYPE

for all Pressures *for all Temperatures*

SHIPMENTS FROM STOCK

W. B. CONNOR, INC.
223 WEST 33rd STREET NEW YORK CITY
MANUFACTURERS OF ACE PRODUCTS

Feed Water Regulation
Pump Regulation

The list of "S-C" Feed Water Regulator installations in the central station and industrial field covers thousands of plants. Reorders over a long term of years proves their high standing. Before specifying Feed Water Regulators, check up general specifications of the "S-C" with others. Used on three of the 650 lb. steam plants built in 1924.

Your pump regulation is just as important, and for this reason let us tell you what we can do for regulation on reciprocating, turbine driven and electric driven pumps.

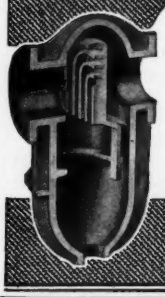
Send for Catalog No. 140.

The "S-C" Regulator Mfg. Co.

Mechanical Regulation Engineers

Fostoria, Ohio

STEAM SEPARATORS



Webster Steam Separator baffles are heavily ribbed and act as impact surfaces, changing direction of flow of steam and catching water which flows down to drain outlet. Ask for Bulletin 301-A.

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Established 1888

Camden, N. J. **46 U. S. Branches**

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"Quality First"

—our standard and constant aim for over 30 years. How well we have realized it is best proven by the service records of over 495,000

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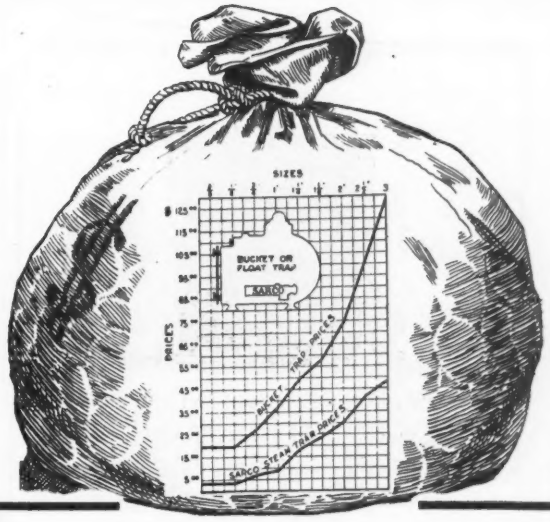
Seamless Copper Floats

Originated by us, they are made in sizes and shapes for every service including superheat and highest pressures. Coated for chemical service. For catalogue write to—Hercules Float Works, 215 Franklin St., Springfield, Mass.



It Costs Much Less to Buy a Sarco

Look at the above illustration and compare the size of a Sarco with that of a bucket or float trap with the identical drainage capacity.

You don't pay for useless metal or a hot-water storage space in the Sarco. That, and the fact that the Sarco has but five parts against as many as forty-three in some traps, explains why you can buy the Sarco for about one-third the price of the larger traps.

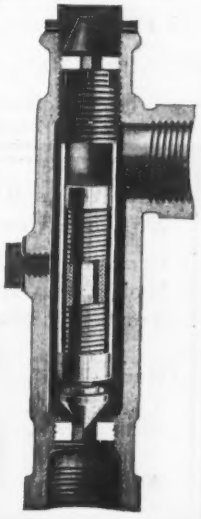
Less parts mean fewer parts to get out of order—fewer parts to carry in stock.

Moreover, it costs less to install the Sarco. It screws into the pipe line at any angle, eliminating the expense of a platform, pit or supports.

Try It Free

Let us send you a Sarco on 30 days' free trial. Without any risk on your part, it will prove to you the fallacy of paying high prices for traps that do no more work.

Simply ask for Booklet B-155 and state the size of trap and temperature for which it will be used.



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Peacock Bros., Limited, Montreal

STEAM TRAP SARCO

IN this book you will find information regarding one of the most important improvements ever made in Shower Bath Equipment

Have you a copy of this book?

ENGINEERS who have anything to do with shower baths will profit by reading this thoroughly practical and interesting book. Upon request we shall be glad to send you a copy without cost or obligation.

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2769 Greenview Ave., CHICAGO.

Gentlemen: Kindly send me a copy of your book, "How to Prevent Scalding and Repair Troubles in Shower Baths."

Name .....

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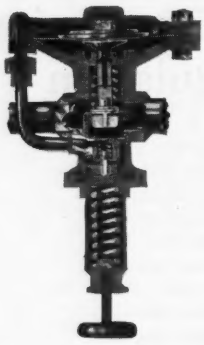


Type 90 F Pressure Regulator is single-seated, self contained, sensitive and accurate. Unexcelled for either steam or air, and is particularly adapted to dead end service. Ask for Bulletin No. 210, containing chart for selecting the correct size of regulator.

Built to Last

and as sensitive to pressure changes as the finger tips, are the complete line of

FISHER Pressure Regulators

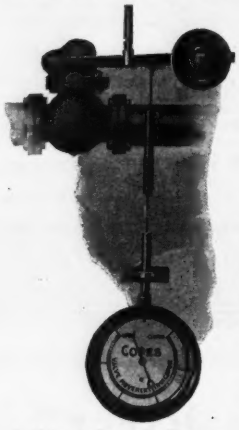
A successful record of more than 40 years has established their leadership in American industries.

The Fisher Governor Company

Dependable Power Plant Specialties

665 Fisher Avenue Marshalltown, Iowa

COPES Valve Movement Indicator



Provides, at eye level, an accurate check on the feed water control valve.

Plant operators should have at all times an accurate check on the movement of the valve which controls the flow of boiler feed water. But on many boilers this valve is not visible from the boiler room floor.

With the COPES Valve Movement Indicator attendants can quickly read, at eye level, the movement of this valve similar to the reading of steam flow, water flow, draft and CO_2.

Can be attached to practically any make of feed water regulator. The dial can be placed anywhere in the boiler room.

While its usefulness in every day service will be apparent, it is especially valuable for making comparisons between feed water regulators.

Bulletin No. 10, giving complete information on the COPES Valve Movement Indicator will be sent you promptly on request.

NORTHERN EQUIPMENT CO., 113 Grove Drive, ERIE, PA.

Branch Plants: London, England; Paris, France; Hamilton, Ontario, Canada; Merseburg, Germany; Vienna, Austria; Milan, Italy.

Unvarying Water Level

Consistently holding water in your boilers to a predetermined level, is the function of the **Squires Boiler Feed Water Controller.**

It is simple in construction, positive in operation, and its few working parts are easily accessible. Repairs can thus be made without removing body from the line.

Ask us to show you how the **Squires Boiler Feed Water Controller** will increase your boiler efficiency.

Trade-Mark Reg. U. S. Patent Office

Catalog A-12 fully describes it.

THE C. E. SQUIRES CO.
E. 40th St. and Kelley Ave., Cleveland, Ohio

FOSTER ENGINEERING CO.

Main Office and Factory, 100 Monroe St., Newark, N. J.

Class "G" Pressure Regulator | Water Pressure Regulator | Fan Engine Regulator

Foster Valves

Pressure Regulators
Pump Governors
Non-return Stop Valves
Emergency Stop Valves
Float Valves
Fan Engine Regulators
Back Pressure Valves

Pump Governor

Turbine Pump Governors
Vacuum Pump Governors
Lever Balanced Valves
Altitude Valves
Elevator Pump Governors
Hydraulic Regulating Valves
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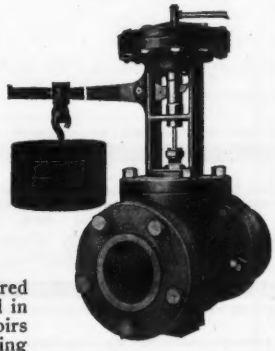
CATALOG No. 50, ON REQUEST

Assure a Continuous Water Pressure by a

Fulton Tank Governor



Whatever head is desired may be steadily maintained in tanks, standpipes, reservoirs or water mains by installing a **Fulton Tank Governor.** This is a heavy, double-seated balanced valve, the stem engaging with a weighted lever. Automatic in operation. Pressure on the diaphragm closes the valve when the desired pressure is reached. When pressure decreases the weighted lever opens the valve. No float valves or electrical devices.

Head to be carried may be increased or diminished by increasing or decreasing the weights.

Extremely delicate in operation. Meets the most exacting conditions.

The Chaplin-Fulton Mfg. Co.
28-36 Penn. Ave. Pittsburgh, Pa.
Manufacturers of the Vigilant Feed Water Regulator, Fulton Pump Governor, Tank Governor and Other Steam Specialties.

Constant Level
Automatically Maintained

in the boiler regardless of variations in load, or the pressure carried, is assured by installing the

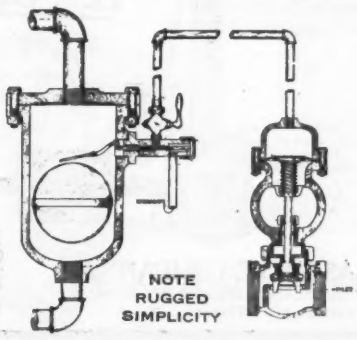
Cleveland Feed Water Regulator

This ensures dry steam, saves cylinder oil, prevents boiler from priming and increases effectiveness of feed water heaters through the uniform flow of feed water.

The **Cleveland** in 6 months will earn its cost in the savings it effects. Savings, safety and service are all typified by this sturdy device.

The Cleveland Feed Water Regulator Co.
2734 Tennyson Road Cleveland, Ohio

Send for Bulletin



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Steady Profit Building Pressure Regulation

is only possible with reducing valves that have the high reputation and capable organization in back of them possessed by

MASON

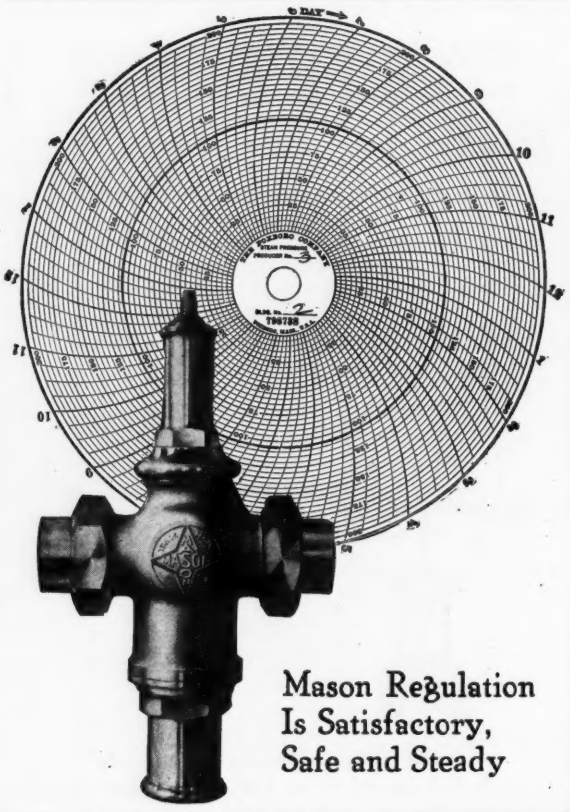
Reducing Valves

They assure steady operation and automatically and accurately control pressures on steam, air or water.

Danger and lack of dependability of the human element need not be considered where Mason Regulation is adopted. The fuel, time and labor it saves, too, is worthy of consideration.

Send for free 220-page catalog.

Mason Regulator Company
Dorchester Center Boston, Mass.



Mason Regulation Is Satisfactory, Safe and Steady

CURTIS ENGINEERING SPECIALTIES

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Steam Pressure Regulator. Temperature Regulator.
Water Pressure Regulator. Balanced Valve.
Steam Traps. Tank Valves.

Send for circulars and No. 53 Catalogue.

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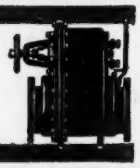
D'ESTE

THE BLACKBURN-SMITH MULTI-DUCT STRAINER

Protects condensers, pumps, etc., from foreign solids in water supply. Easy to clean and dependable.
Write for Bulletin S-209.

The Blackburn-Smith Corporation
23 West 45th Street, New York



Bulletin No. 5A on VICTOR Damper Regulators is just off the press

No. 1 is for pressures up to 25 lb.; No. 2 up to 150 lb.; No. 3 up to 250 lb. Sold with an **absolute guarantee.**

See classified directory, this issue; for all other Atlas Regulating devices.

Write for it!

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REGULATING VALVES FOR EVERY SERVICE
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600 catalogues — See our Catalogue in SWEET'S — in one volume

For Buying Facts

Regarding Industrial and Power Plant Materials and Equipment See

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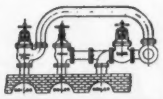
The Large Iron and Steel Corps. Order "4400"

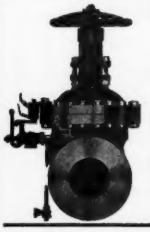


DOUBLE EXTRA HEAVY VALVES "Every Valve sold with a positive Guarantee."

"No Shut-down when Boiler Tube Bursts"

Golden-Anderson Patent Automatic Double Cushioned, Triple Acting; and also Non-Return Valves

1. Prevent expensive shutdowns due to reversal of steam flow.
2. Instantly close and isolate a boiler when a tube ruptures.
3. Simultaneously shut off the steam flow from all boilers when a pipe bursts.
4. Automatically cut a boiler into the line.
5. Prevent back flow of steam into a cold boiler.
6. Positive fool-proof. No springs or adjustments to be made.
7. Can be tested in service.
8. "Double Corliss" dash pot that cushions in opening and closing.
9. Cannot spin, stick or chatter.



Golden-Anderson Patent Cushioned Combined Throttle and Automatic Engine Stop Valves

1. Operate 3 ways: Automatically, by Hand, or by Electric Switch.
2. Prevent Fly-Wheel Explosions.
3. "Double Corliss" Cushioned—No Pounding or Sticking.
4. Contain No Tight Fitting Parts.
5. Furnished in Angle and Globe Patterns for High or Low Pressures.
6. "Always Ready for Service."

Golden-Anderson Patent Automatic Cushioned Steam Pressure Reducing Valves

Automatically hold the reduced steam pressure constant.

Fitted with patent safety piston that prevents high pressure escaping to low pressure side.

Golden-Anderson Patent Automatic Double Cushion Check Valve

Especially adapted for Hydraulic Elevator Service and on discharge side of pumps. Sizes to 30 inches.

Golden-Anderson Patent Automatic Controlling Altitude Valves

Automatically maintain uniform water level in tank, standpipe or reservoir. No floats or fixtures.

Sizes to 30 inches.

GOLDEN-ANDERSON VALVE SPECIALTY CO.

1287 Fulton Building

PITTSBURGH, PA.

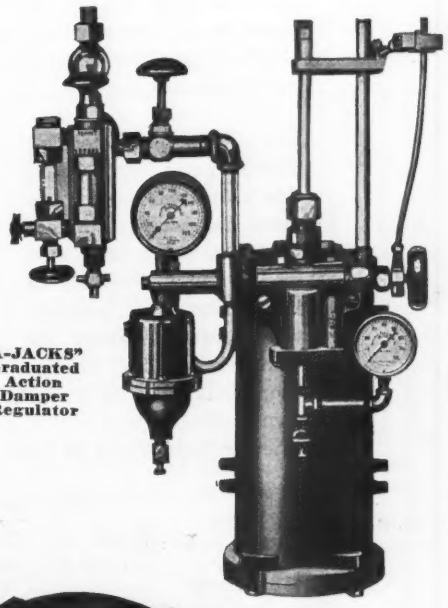
Let them keep your expenses down

Have you ever estimated how many dollars you have lost in plant operation simply because you had to deal with "human error?" Statistics tell that "human error" losses are enormous. Every error that you can avoid by substituting an automatic and absolutely dependable apparatus will mean that much extra money in your pocket. We know of many of our customers who paid for our apparatus within a month's time in the amount of fuel it saved.

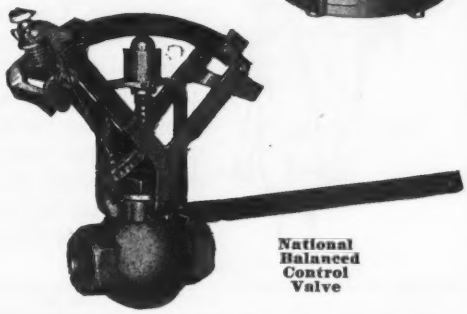
Write for full literature on our improved method of automatic draft control.

The National Regulator Co.

2301 Knox Ave. Chicago, Ill.



"A-JACKS" Graduated Action Damper Regulator

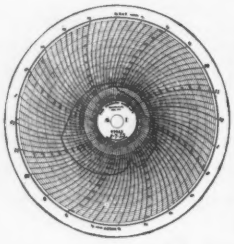


National Balanced Control Valve

Shut that door!

was written as plain as a newspaper scare head on the recording thermometer chart illustrated. A painter had left the door of the paint baking kiln open, but the watchman had been taught to read the chart.

$1500 worth of beds were saved



The chart shown was the means of saving them. Heat was turned on at 12:45 p.m. At 5:25 a painter opened the kiln to put in a few beds and carelessly *left the door open.*

The watchman, seeing the drop in temperature on the chart, shut the door and saved the beds. The heat was then maintained for the proper time, turned off at 11:50 and the kilns allowed to cool gradually until morning.

The Foxboro Recording Thermometer, from which this chart was taken, has saved thousands of dollars for its owner, a metal bed manufacturer. Previous to installation the engineer was unjustly blamed for heavy losses due to improper baking of the enamel, when, in his own words, "It was a 50-50 gamble as to whether beds would be baked or fried."

Other Savings

Equal and even greater savings are constantly being reported. One manufacturer recently reduced his annual coal bill $3,000 to $4,000; another saved enough to pay for his instruments the first two weeks they were installed and estimates his annual savings at $2,000 to $3,000; and there are countless similar examples wherever temperature, pressure or humidity is a factor.

In Your Particular Case

Do *your* men know the real significance of temperature and pressure records? Do you yourself realize how valuable they can be?

Read your charts! They perpetuate daily experience. They show why one way is right and another is wrong. Study them and you can base all your decisions on fact. Often they provide the only tangible evidence of your value to the company. They write the most interesting story ever told — a minute-to-minute account of your own accomplishment.

Make sure of the reliability of these vitally important records. Specify Foxboro Recording Thermometers and Gauges with the Improved Helical Tube Movement, guaranteed to be accurate no matter how severe the service conditions.

Let us help you. Write for Bulletin "D" 96-1.

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6949

An Achievement *in* Temperature Service

Closer and more dependable temperature records are assured, as the result of more than thirty years of constant research and experience, by

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BRISTOL'S
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Recording Thermometers

For air, gas, oil, steam—in fact furnished for successful application on every conceivable type of service.

Bristol's Charts are standard records. Depend on them to give you a better operation and more uniform operation, less fuel and heat waste.

Bristol's Recording Thermometers on inlet and outlet of heaters, and economizers, steam lines, oil reservoirs, turbine bearings, transformers, etc., show each temperature variation and time it occurs.

Write for our Catalogue O-1302.

You Need

Bristol Records of Pressure, Temperature, Current, Voltage, Kilowatts, Water Level, Production, Motion, etc. Ask us about dividend - paying applications.

THE BRISTOL COMPANY, Waterbury, Conn.

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Determine CO_2 *Electrically*

Know whether you have complete combustion or waste—and determine it electrically by using BACHARACH Electric CO_2 Meters (S. & H. Type). Simple in design, ever reliable, no delicate parts, no chemicals, no time lag. The readings are always reliable under any and all conditions and may be continuously recorded on a chart in the engineers' office. To maintain high combustion efficiency you can depend upon Bacharach Electric CO_2 and CO Meters and Bacharach Recorders.

Write for our special bulletin 250

Bacharach Industrial Instrument Co.
7006 Bennett St. Pittsburgh, Pa.

BACHARACH *INDUSTRIAL INSTRUMENTS*

A Healthy Steam Plant

like a healthy person gives **snappy, vigorous** and **efficient service.**

If boiler tubes are cleaned with a **HURRICANE Flue Cleaner** its steaming efficiency is greatly increased.

If boiler draft is controlled by a **SPENCER DAMPER REGULATOR** you add to its life and get nearly 100% coal strength.

If engine is indicated with a **ROBERTSON-THOMPSON INDICATOR** you can know it is delivering full power.

If engine and pumps are packed with **EUREKA PACKING** you remove friction and secure great horse power.

Shutting Down Time

is an excellent time to include these economical and helpful additions in your plant. They don't cost much.

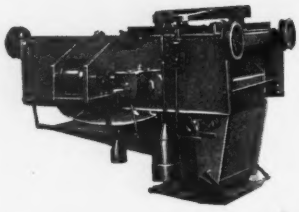
Robertson-Eureka
71-81 Murray Street New York

Watch the

Coal Consumption!

And keep your boilers operating at highest standards. A boiler consuming an extraordinary amount of coal without producing an equivalent amount of power means a loss. Install

Richardson Coal Scales



and know you are getting maximum efficiency from every unit!

Weighs dry, wet, sulphurous, lumpy and fine coal with equal facility and without error.

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PASSAIC, NEW JERSEY
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APEX CO_2 RECORDER

IDEAL FOR THE SMALL PLANT
Simple Accurate Inexpensive
Send for bulletin describing this new instrument
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To Burn Coal with Economy

you must have a record of how much is burned under each boiler.

C. J. COAL METERS

meter and record each charge fed to boilers, and furnish a check on the efficiency of fuel and firemen. Compact, dependable and inexpensive. Write for literature.

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"Republic CO_2 Recorders"
"Republic Model SFC"
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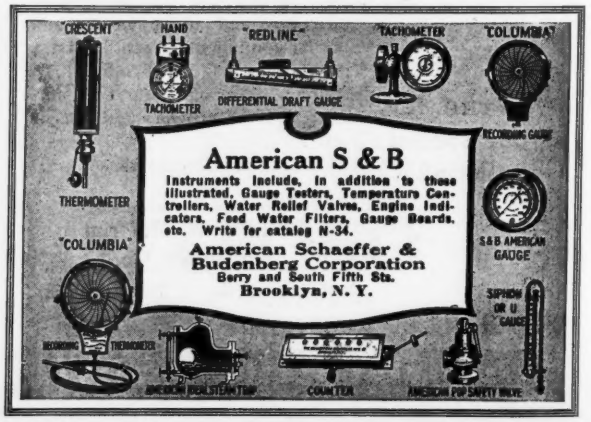
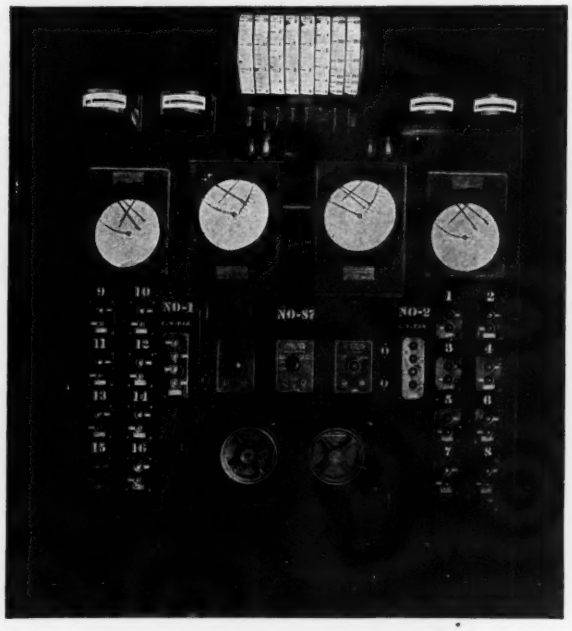
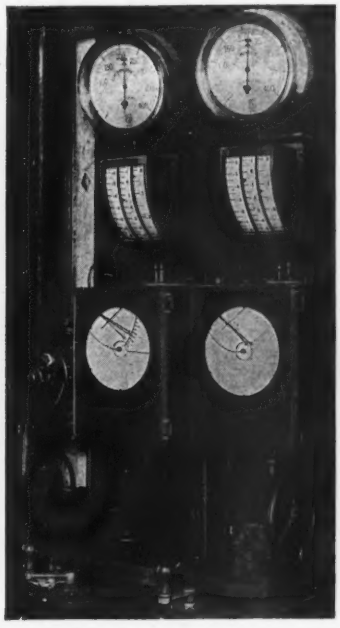
Check the ones you want, write your name on the margin; mail to—

Republic Flow Meters Co., 2224 Diversey Pkwy., Chicago







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There is one reliable method of keeping an accurate account of the performance of each boiler unit.

This method enables you to have continuous records of Steam Flow, Air Flow used for combustion, Flue Gas Temperature and Coal Feed.

The Bailey Meter will solve this problem to your entire satisfaction.

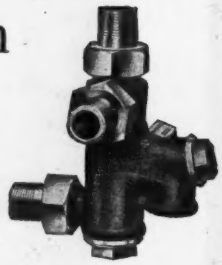
Write for Bulletins No. 42 and 161

BAILEY METER COMPANY

2013 E. 46th St., Cleveland, O.

Bailey Meter Company, Ltd., 179 Delorimier Ave., Montreal

Every One Tested in Operation



on an independent boiler, under actual working conditions in our factory before shipment That's why we are **sure** that every Penberthy is absolutely dependable. And that's why over a million and a quarter

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Automatic Injectors

have made good protecting boilers from the danger of sudden break in feed water pump.

This is only one of many features of this famous member of the famous Penberthy Line.

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Then your feed water should be analyzed. Maybe you are literally pouring cement into your boiler. Turbining, tube loss, loss of fuel, expense of shutdown, are due to hard water, and our business is to soften it.

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PAIGE-JONES Offer Unbiased Selection of ALL Types of Water Softening Systems

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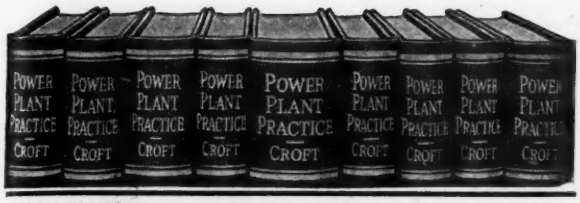

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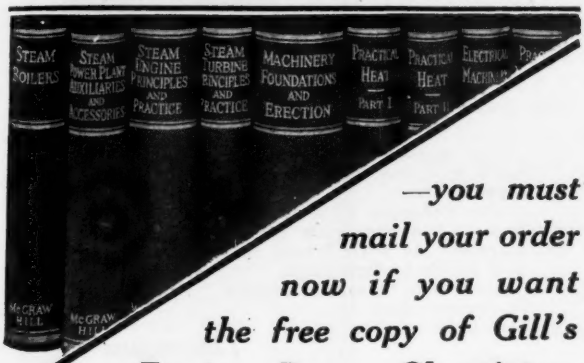

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P. P. E. 12-15-24

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There never was such a real opportunity in any one occupation to push ahead rapidly as there is in the field of Combustion Engineering. With high-grade fuel becoming scarce, with the price 300 per cent higher than just a few years ago, the man who knows how to prevent waste in the burning of fuel has wonderful opportunities.

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Every plant, sooner or later, will require the services of a man who can cut down fuel expenses and promote efficient plant management. By learning Combustion now, you are preparing yourself for the increasing number of big jobs that are opening up every day for the man who knows.

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Now is the time to get started in the field of Combustion Engineering. Although you may not have made much progress during the past few years, you will find in the Hays Course a real stepping stone to bigger jobs—bigger pay.

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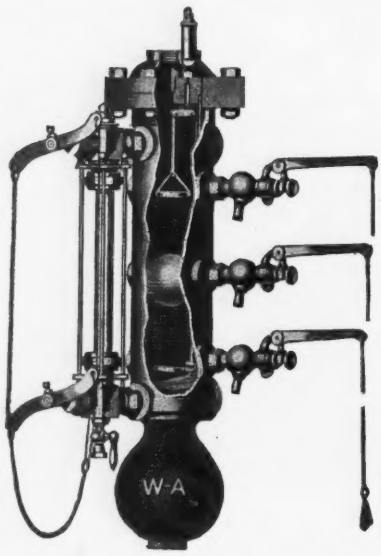
Engineers Prefer Wright-Austin Water Alarm Columns



Engineers no longer ask, "Shall we use safety alarm water columns on our boilers?" Because of their absolute reliability Wright-Austin Alarm Columns are provided on the most modern boiler installations and are specified by leading engineers.

Wright-Austin Safety Water Alarm Columns are the perfected product of an organization that has been producing them since 1894. Design is simple, workmanship exact, action positive. They are always on the job. The best of materials assures them long life. Write us for new bulletin.

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Steam Traps
Strainers
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Steam and Oil Separators
Boiler Alarm Water Columns

WRIGHT AUSTIN
STEAM SAVING EQUIPMENT

They Are Trouble Savers and May Save Your Eyesight from Splintered Glass

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"The Unbreakable Gauge Glass"

Two **semi-metallic** substances made into one **clear pressure-resisting** tube!

The Reflecting Type with its back of **red** and **white** enamel magnifies the water line so that it is **visible in dark** places.

Send to us or ask for address of nearest agent.

Reflecting Type Sonderglass

This means added safety!

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Soot Blowers for water tube boilers; for fire tube boilers; Hand Fire Stokers; Marion Scottdale Grates; Marion Interlocking Grates; Marion Rocking and Dumping Grates; Keystone Rocking and Dumping Grates; Portable Kiln Grates; Forced Draft Blowers; Boiler Fronts, etc.; Coal Mining Equipment; Coal Crushers, Coal and Coke Handling Machinery, Gas and Oil Engines.

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Dependable long service is one benefit from Moncrieff Glasses. Safety to workmen and boilers is another. Tough and clear, the genuine Scotch glass endures. Violent temperature changes — zero drafts — a Moncrieff meets without mishap.

Get a trial dozen and prove them. Write for bulletin.

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H. A. ROGERS CO. UNIFIC GAUGE GLASS MONCRIEFF MAKER PERTH SOLE AGENTS FOR UNITED STATES MADE IN SCOTLAND

Perth Brand for pressures up to 200 lb.
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This is the Reliance Seamless Float, made absolutely without seam or solder, of unusual strength and great buoyancy, for high pressure work.

floats that stand w. s. p. of 500 pounds—easily!

THE Reliance Nickel Jacketed Float, with a remarkable buoyancy, is guaranteed for working steam pressures of 500 pounds. This means that it is more than strong enough to take the 750-pound hydrostatic boiler tests. No need to remove it from the column.

We HAD to develop floats of extraordinary strength and reliability, for floats are the heart of Reliance Columns. And Reliance Columns have a reputation for integrity that must be maintained.

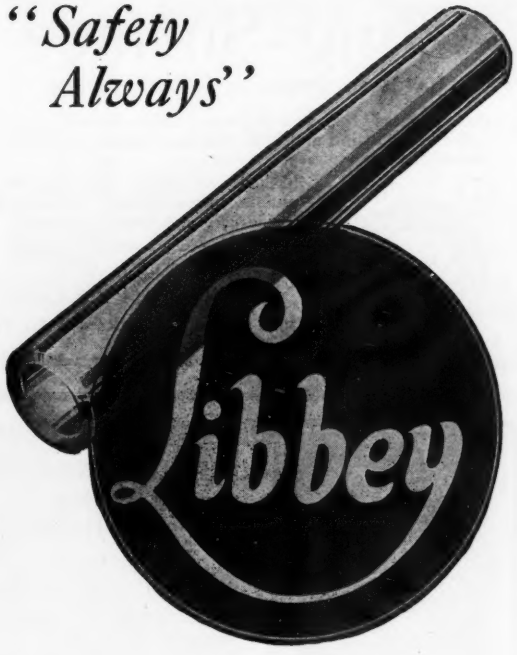
We have or can make floats for any pressure up to 1000 pounds. Write for complete information.

The Reliance Gauge Column Company
5932 Carnegie Ave. Cleveland, Ohio

Reliance

TRADE MARK REG. IN U.S. PAT. OFF.

"Safety Always"



High Pressure Gauge Glasses

There's Economy in the Service

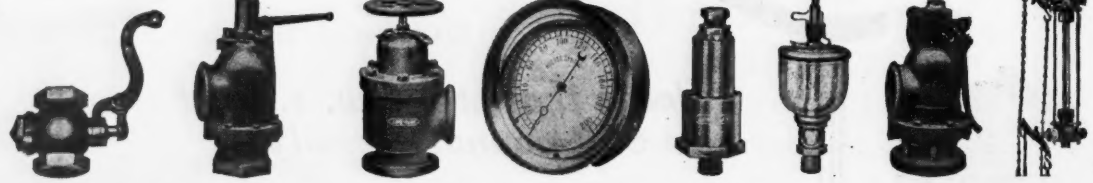
given by these gauge glasses that are cold, draft, splash and cloud-proof and guaranteed for 400 lbs. pressure. That's why leading industries specify Libbey.

For more than a hundred years we have made glass in America, and so today are producing this gauge glass that, being unexcelled anywhere, is known as

"America's Standard Gauge Glass"

sold in packages of six by dealers, or, if not in stock, order a dozen direct from us.

The Libbey Glass Mfg. Co.
Toledo, Ohio


Plain Whistle Valve Model "PWV"
Pop Safety Valve Model "A"
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Describes over 300 appliances for hydraulic, steam, gas, air, oil and ammonia service that are in use all over the world, assuring safety and economy and noted for their durability and dependability.

If you do not have this 128-page handbook with useful data and tables, send us name and address so we can mail a copy when off press.

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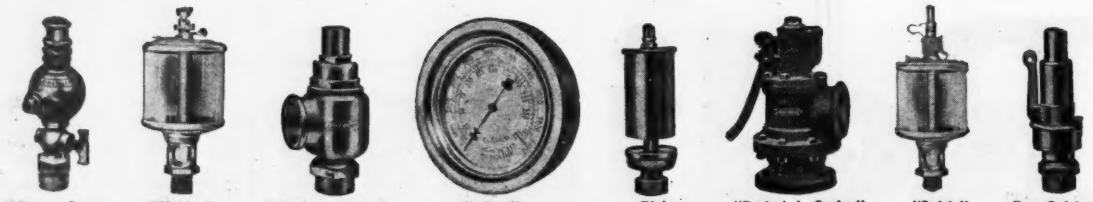
Steam Gauge Syphon Model "CCS"
"Yankee" Sight Feed Oil Cup
"Marine" Cylinder Relief Valve Model "T"
Hydraulic Gauge Model "GH"
Plain Whistle Model "PNV"
"Protected Spring" Pop Safety Valve Model "B"
"Safety" Oil Cup
Pop Safety Valve Model "K"

In Need of a Real Flue Cleaner?

Get the

PILLEY

Combination Flue Brush and Scraper

Price $1.00 per Diameter Inch

and you'll find it will clean out the fire tubes rapidly, thoroughly and with easy operation.

A turn of the handle contracts the iron teeth of the scraper so as to enter the flues easily.

The brush of fine strong wire brushes out all soot, ash and scale the claws dig off, leaving the tubes like new.

Made to fit all tubes from 2-in. to 6-in. diameter.

Details on request—Your Jobber Sells Them

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The Belt Preservative—Lubricant

that assures full power from slack-running belts, eliminates tension and slip, reduces friction and lubrication costs.

Makes and keeps belts mellow, pliable, water-proof; preserved for longer and better service.

F. O. B. Warehouse Stocks in Different Centers.

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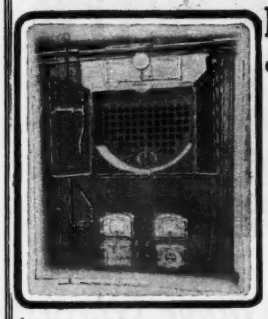

Diamond Soot Blowers a profitable investment on Return Tubular Boilers

They save 4 to 8% fuel. Save 50% steam required for operation, as compared to the hand lance.

And their use results in increased boiler capacity.

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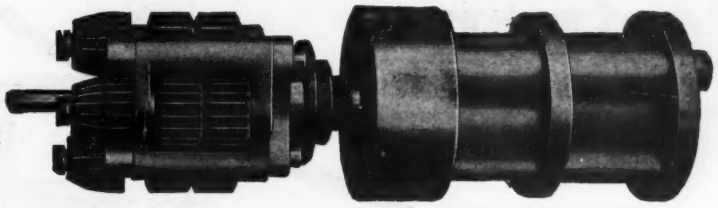
Diamond Power Specialty Corporation
DETROIT, MICHIGAN

An Important Problem

The Removal of Scale Deposits



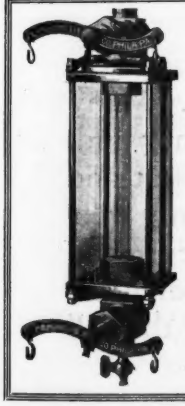
The Answer

Roto Tube Cleaners

Fast Thorough Safe

The Roto Company

HARTFORD, CONN.



Prevent Serious Losses

both in efficiency and the personnel of your plant. For over 25 years, engineers have been guarding their plants from inefficiency and their men from injury through the use of

"P. B. H." Steam Specialties

"P. B. H." Gauge Glass Protector shown at left attached to a "P. B. H." chain quick-closing water gauge prevents blindness, scalds or cuts when a gauge glass bursts. Easily installed on any size gauge. Better order before you experience such an accident. State distance between inside faces of rod plates on your gauge valve.

"P. B. H." Self-Closing Weighted Gauge Cock positively will not leak when closed. Instantly opened from the boiler room floor. When released, the weighted lever immediately closes the valve again. The wear-resisting metal valve pencil is of special design. When worn it can be replaced at a cost of a few cents. No regrinding ever required.

Prices Right

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Satisfaction Guaranteed

The PAUL B. HUYETTE CO., Inc., Suite 3, 5 South 18th St., Philadelphia, Pa.

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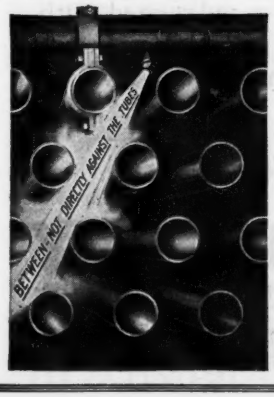


VULCAN DIAGONAL METHOD of BLOWING

takes advantage of the diagonals formed by the tubes, in the staggered tube type of boilers, through which cleaning jets of steam can pass, scrubbing along the tubes clear to the bottom row, but never directly against them.

Special bulletins describing Vulcans for various types of boilers will be gladly sent on request.

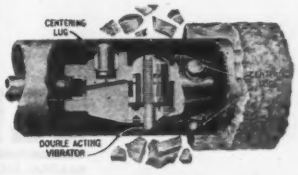
Vulcan Soot Cleaner Co.

Vulcan Bldg. Dubois, Pa.

Send a "Torpedo" After Scale

Sixty thousand fire tube boilers were cleaned of scale last year by the "Torpedo." It finds scale where inspectors cannot.

The "Torpedo" does its work rapidly—from 2 to 4 hours per boiler and **cleans thoroughly.**



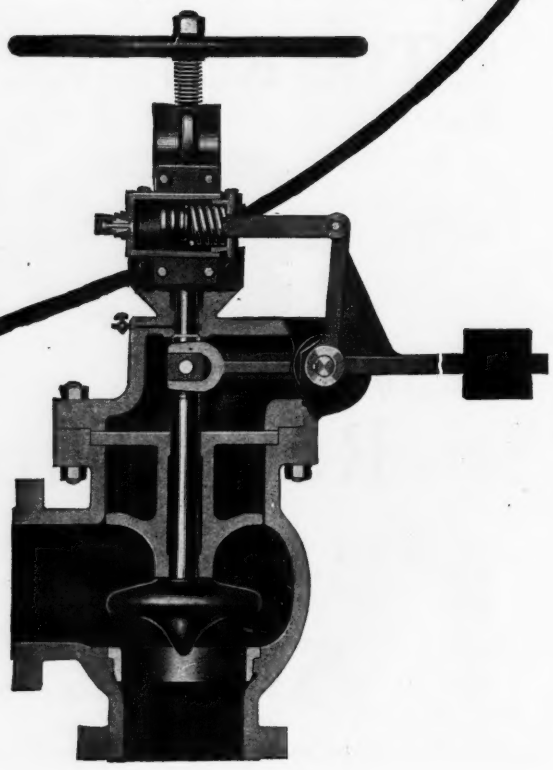
Operated by either air or steam, it taps the tube wall lightly at the rate of 11,000 times a minute. The vibrations crack and shake off the brittle scale. No injury to tubes results.

We will gladly send you a "Torpedo" for free trial on one boiler. Write us.

The General Specialty Company

70 Carroll Street - - - - - Buffalo, N. Y.

"Stream-Line Flow" Non-Return Valve



for
High Pressure
High Temperature
Service

Stream Line Flow
External Dash-Pot
Indicating Arm
Low Pressure Drop
Line Seating Contact

The construction of these Valves is such as to reduce pressure drop to a minimum. Many points in design contribute to this end. There is a venturi throat between seat and disc. The seat has no supporting web. There are no pockets to cause eddy currents. The moving parts are partially balanced, and do not have to be supported by the full steam flow.

This valve is designed for high pressure, high superheat service. Construction is heavy and rugged, with ample factor of safety. The external dash-pot makes it the most effective Non-Return Valve yet designed.

Ask for descriptive Bulletin S-5

ELLIOTT COMPANY

GENERAL SALES OFFICES AND WORKS
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PRODUCTS
CONDENSERS, AIR EJECTORS, FILTERS, DEAERATORS, STRAINERS, SEPARATORS, GREASE EXTRACTORS, AUTOMATIC VALVES, BLOW-OFF VALVES, HEATERS . . . .

S-1086

BIG HEATERS
FOR BIG PEOPLE

THE photographs are only illustrative of a few of our many recent shipments of large size heaters. Many more could be mentioned, for example:

THE PUBLIC SERVICE ELECTRIC POWER CO. recently bought five Cochrane Deaerating and Metering equipments of 400,000 lb. per hour capacity each.

THE OHIO RIVER EDISON CO. bought six Cochrane Closed Heaters and four Cochrane Jet Heaters of 375,000 lb. per hour capacity each.

THE MONTAUP ELECTRIC CO., Fall River, Mass., bought two Cochrane Extraction Heaters for their 30,000 kw. turbine.

THE UNION ELECTRIC LIGHT & POWER CO., of East St. Louis, Ill., bought two Cochrane Deaerating Heaters, one of 720,000 lb. per hour capacity and the other of 330,000 lb. per hour capacity.

THE COLUMBUS RAILWAY LIGHT & POWER CO. purchased two Cochrane Feed Water Heating Systems of 350,000 lb. per hour capacity each, including Deaerating Heaters and Closed Extraction Heaters.

THE NEW YORK EDISON CO. has bought for No. 2 Waterside Station a 1,000,000 lb. per hour Cochrane Heater.

THE WEST PENN POWER CO. has two Cochrane Deaerating Heaters of 400,000 lb. per hour capacity each.

THE PACIFIC GAS & ELECTRIC CO. purchased a Cochrane Heater of 250,000 lb. per hour capacity.

THE FITCHBURG GAS & ELECTRIC CO., Fitchburg, Mass., bought a 250,000 lb. per hour Cochrane Deaerating Heater.

THE BINGHAMTON LIGHT, HEAT & POWER CO. bought a 500,000 lb. per hour Cochrane Jet Heater with surge tank.

THE EAST PENN ELECTRIC CO. has a 380,000 lb. per hour Cochrane Deaerating Heater in the Pine Grove Station.

THE SOUTHERN POWER CO., Charlotte, N. C., is installing 1,350,000 lb. per hour of heaters in their Eno, Mt. Holly and Tiger Stations.

THE COUNTIES GAS & ELECTRIC CO. has a 300,000 lb. per hour Cochrane Metering Heater in the Barbadoes Island Station, and so on.

Whatever your water heating, metering, deaerating, softening or filtering requirements may be, our Engineers can show you something of interest. Ask for Booklet H, "Feed Water Heaters in Their Relation to Steam Plant Efficiency."

COCHRANE CORPORATION

Formerly Harrison Safety Boiler Works

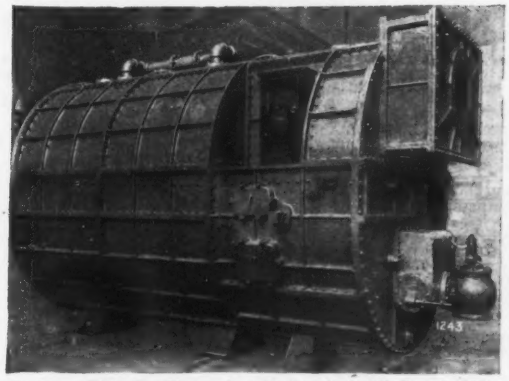
3144 North 17th Street, Philadelphia, Pa.

Offices at Atlanta, Baltimore, Birmingham, Boston, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, El Paso, Greenville, S. C.; Hazleton, Pa.; Houston, Indianapolis, Kansas City, Little Rock, Los Angeles, Memphis, Minneapolis, New Orleans, New York, Omaha, Phoenix, Pittsburgh, Portland, Richmond, Rochester, St. Louis, Salt Lake City, San Antonio, San Francisco, Seattle, Syracuse, Washington, D. C., Toronto, Montreal, Halifax, Vancouver.

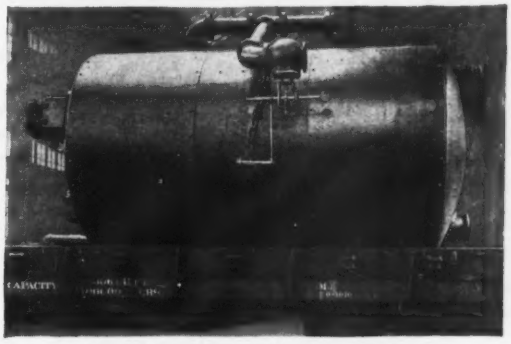
London—Norman Engineering Co., 23 Budge Row

"TO ECONOMIZE—COCHRANIZE"

One of two Cochrane Metering Heaters for the Delaware County Electric Co., Chester Station, 750,000 lb. per hr. each.



Cochrane Metering Heater for the Standard Oil Co. of Ohio; 300,000 lb. per hr. at 15 lb. gage back pressure.



Cochrane Heater for the American Printing Co., Fall River, Mass.; 400,000 lb. per hr.

Cochrane Heater for the Atlantic Mills, Providence, R. I.; 350,000 lb. per hr.

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COAL BUNKERS, CAST IRON, CATENARY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.

COAL CRUSHERS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Fuller-Lehigh Co., Fullerton, Pa.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

COAL STORAGE EQUIPMENT.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

COAL WEIGHING AND MEASURING EQUIPMENT.
C. J. Mfg. Co., Philadelphia, Pa.
Richardson Scale Co., Passaic, N. J.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

COCKS, AIR AND STEAM.
Dart Mfg. Co., E. M., Providence, R. I.
Kelly & Jones Co., The, Greensburg, Pa.
Powell Co., Wm., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, O.

COCKS, BLOWOFF.
Scully Steel & Iron Co., Chicago.

COILS AND BENDS.
Badger & Sons Co., E. B., Boston, Mass.
National Pipe Bending Co., The, New Haven, Conn.

COMBUSTION APPLIANCES.
Bacharach Ind. Instrument Co., Pittsburgh, Pa.
Republic Flow Meters Co., Chicago, Ill.
Uehling Instrument Co., Paterson, N. J.

COMBUSTION (CO_2) RECORDERS.
Bacharach Ind. Instrument Co., Pittsburgh, Pa.
Foxboro Co., Inc., The, Foxboro, Mass.
Huyette Co., Inc., The Paul B., Philadelphia.
Pierce Co., The Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.
Uehling Instrument Co., Paterson, N. J.

COMMUTATOR COMPOUND.
Ohio Grease Co., Loudonville, O.

COMMUTATOR DRESSER.
Ideal Commutator Dresser Co., Sycamore, Ill.

COMPOUND, PIPE JOINT.
Dixon Crucible Co., Jos., Jersey City, N. J.
Smooth-On Mfg. Co., Jersey City, N. J.

CONCRETE ARMORING, SURFACE
Irving Iron Works Co., Long Island City, N. Y.

CONDENSERS.
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis, Ind.
Elliott Company, Jeannette, Pa.
Griscom-Russell Co., New York.
Ingersoll-Rand Co., New York.
Manistee Iron Works, Manistee, Mich.
Ross Heater & Mfg. Co., Buffalo.
Schutte & Koerting Co., Phila.
Standard Water Systems Co. of N. J., Hampton, N. J.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Worthington Pump & Machinery Corp., New York, N. Y.

CONDENSER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

CONDUIT, FIBRE.
Johns-Manville, Inc., New York.

CONVEYORS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago, Ill.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Combustion Engineering Corp., New York, N. Y.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Girtanner Engineering Corp., New York, N. Y.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

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Griscom-Russell Co., New York.
Ross Heater & Mfg. Co., Buffalo, N. Y.
Schutte & Koerting Co., Phila.

COOLING SYSTEMS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, N. Y.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Yarnall-Waring Co., Philadelphia, Pa.

COOLING TOWERS.
Cooling Tower Co., Inc., The, N. Y.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.

COUNTERS, REVOLUTION.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Lonergan Co., J. E., Phila.

COUPLINGS, COMPRESSION SHAFT.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, UNION.
Dart Mfg. Co., E. M., Providence, R. I.
Kelly & Jones Co., The, Greensburg, Pa.

CRANES, LOCOMOTIVE.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.

CUT GEARS.
Earle Gear & Mach. Co., The, Philadelphia, Pa.

DE-AERATORS.
Ross Heater & Mfg. Co., Inc., Buffalo, N. Y.

DIE STOCKS.
Borden Co., The, Warren, Ohio.

DOORS, AIR TIGHT.
Brady Conveyors Corp., Chicago, Ill.
Conveyors Corp. of America, Chicago.

DRYERS, ROTARY.
Fuller-Lehigh Co., Fullerton, Pa.

DYNAMOS AND MOTORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
De Laval Steam Turbine Co., Trenton, N. J.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
General Electric Co., Schenectady, N. Y.
Kerr Turbine Co., Wellsville, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

ECONOMIZERS, FUEL.
Power Specialty Co., New York, N. Y.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.

EJECTORS.
Penberthy Injector Co., Detroit, Mich.
Sherwood Mfg. Co., Buffalo, N. Y.

ELECTRICAL SUPPLIES.
General Electric Co., Schenectady, N. Y.
Ideal Commutator Dresser Co., Sycamore, Ill.

ELIMINATORS, AUTO. STEAM.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Robertson & Sons, Jas. L., N. Y.

ENGINES, GAS AND GASOLINE.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., New York.
Worthington Pump & Machinery Corp., New York, N. Y.

ENGINES, OIL.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., New York.
McIntosh & Seymour Corp., Auburn, N. Y.

ENGINES, STEAM.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
De Laval Steam Turbine Co., Trenton, N. J.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
Erie City Iron Works, Erie, Pa.
Harrisburg Fdry. & Machine Wks., Harrisburg, Pa.
Kerr Turbine Co., Wellsville, N. Y.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
McIntosh & Seymour Corp., Auburn, N. Y.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.
Troy Eng. & Mach. Co., Troy, Pa.
Vilter Mfg. Co., Milwaukee, Wis.

ENGINE STOPS, AUTOMATIC.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

ENGINE TRIMMINGS.
Sherwood Mfg. Co., Buffalo, N. Y.

EVAPORATORS.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Ross Heater & Mfg. Co., Buffalo, N. Y.
Standard Water Systems Co. of N. J., Hampton, N. J.
Sugar Apparatus Mfg. Co., The, Philadelphia, Pa.

EXHAUST HEADS.
Burt Mfg. Co., The, Akron, O.
Hoppes Mfg. Co., Springfield, O.
Patterson-Kelley, New York.
Robertson & Sons, Jas. L., N. Y.
Sims Co., The, Erie, Pa.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit, Mich.

EXPANDERS, TUBE.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

EXTRACTORS, OIL AND GREASE.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Blackburn-Smith Corp., The, New York, N. Y.
Sims Co., The, Erie, Pa.
Standard Water Systems Co. of N. J., Hampton, N. J.

FANS, ELECTRIC.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
General Electric Co., Schenectady, N. Y.
Wing Mfg. Co., L. J., New York.

FANS, EXHAUST AND VENTILATING.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
Kerr Turbine Co., Wellsville, N. Y.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.
Wing Mfg. Co., L. J., New York.

FAUCETS.
Kennedy Valve Mfg. Co., Elmira, N. Y.

FEED WATER FILTERS.
Blackburn-Smith Corp., The, New York, N. Y.
Elliott Company, Jeannette, Pa.
Griscom-Russell Co., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.
Standard Water Systems Co. of N. J., Hampton, N. J.

FEED-WATER HEATERS AND PURIFIERS.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Blackburn-Smith Corp., The, New York, N. Y.
Cochrane Corp., Philadelphia, Pa.
Connor, Inc., W. B., New York, N. Y.
Elliott Company, Jeannette, Pa.
Griscom-Russell Co., New York.
Hoppes Mfg. Co., Springfield O.
National Pipe Bending Co., The, New Haven, Conn.
Patterson-Kelley, New York.
Powers Regulator Co., Chicago.
Robertson & Sons, Jas. L., N. Y.
Ross Heater & Mfg. Co., Buffalo, N. Y.
Schutte & Koerting Co., Phila.
Sims Co., The, Erie, Pa.
Standard Water Systems Co. of N. J., Hampton, N. J.
Stickle Steam Specialties Co., Indianapolis, Ind.
Superheater Co., The, New York.
Webster & Co., Warren, Camden, N. J.
Wheeler Mfg. Co., C. H., Philadelphia, Pa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yarnall-Waring Co., Philadelphia, Pa.

FILTERS, OIL.
Blackburn-Smith Corp., The, New York, N. Y.
Burt Mfg. Co., The, Akron, O.
Elliott Co., Jeannette, Pa.
Wm. W. Nugent Co., Chicago, Ill.
Sims Co., The, Erie, Pa.

FILTRATION APPARATUS.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., The, New York
Power Plant Specialty Co., Chicago, Ill.

FIRE BRICK.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Jointless Fire Brick Co., Chicago.
King Refractories Co., Inc., Buffalo, N. Y.
Liptak Fire Brick Arch Co., Chicago, Ill.
McLeod & Henry Co., Troy, N. Y.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co. Inc., N. Y.

FIRE BRICK CEMENT.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.

FIRE CLAY.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Jointless Fire Brick Co., Chicago.
Obermayer Co., The S., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.

FIRE HYDRANTS
Howard Iron Works, Buffalo, N. Y.

FITTINGS, AMMONIA.
Vilter Mfg. Co., Milwaukee, Wis.

FITTINGS, CAST STEEL AND IRON.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

FITTINGS, COMPRESSION
Wm. W. Nugent Co., Chicago, Ill.

FITTINGS, FLANGE AND PIPE.
Fisher Governor Co., The, Marshalltown, Iowa.
Kelly & Jones Co., The, Greensburg, Pa.
Pittsburgh Valve, Fdry. & Const. Co., Pittsburgh, Pa.
Power Specialty Co., New York.
Reading Steel Casting Co., Inc., Bridgeport, Conn.
Ross Heater & Mfg. Co., Buffalo.
Scully Steel & Iron Co., Chicago.

FLANGES.
Amco Sales Corp., Chicago.
Dart Mfg. Co., E. M., Providence, R. I.
Kelly & Jones Co., The, Greensburg, Pa.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

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Dexter Co., Inc., I. H., Goshen, N. Y.

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Hercules Float Wks., Springfield, Mass.
Reliance Gauge Column Co., Cleveland, Ohio.

FLOORING, NON-SLIPPING
Irving Iron Works Co., Long Island City, N. Y.

FLOORING, OPEN STEEL
Irving Iron Works Co., Long Island City, N. Y.

FLOORING, STEEL
Irving Iron Works Co., Long Island City, N. Y.

FLOORING, VENTILATING
Irving Iron Works Co., Long Island City, N. Y.

FLOOR PLATES.
Scully Steel & Iron Co., Chicago, Ill.

FLOW METERS.
Bacharach Ind. Instrument Co., Pittsburgh, Pa.
Bailey Meter Co., Cleveland, O.
General Electric Co., Schenectady, N. Y.
Republic Flow Meters Co., Chicago, Ill.

FLUE CLEANERS.
Diamond Power Specialty Corp., Detroit, Mich.
General Specialty Co., The, Buffalo, N. Y.
Huyette Co., Inc., The Paul B., Philadelphia.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Sherwood Mfg. Co., Buffalo, N. Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.

FLUE GAS ANALYSIS INSTRUMENTS.
Bacharach Ind. Instrument Co., Pittsburgh, Pa.
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Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
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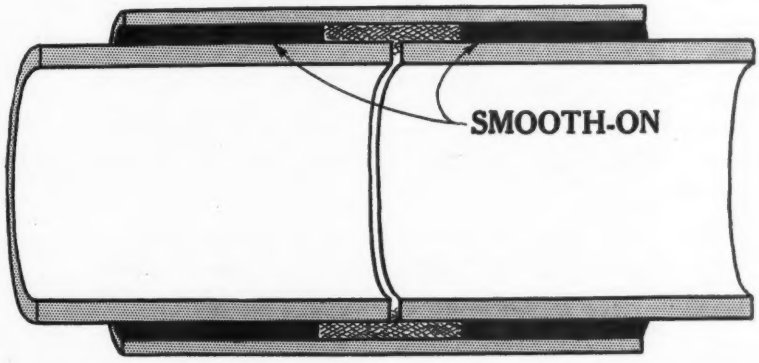

AN emergency joint that is simple to make, permanently tight on steam, water or any other lines at any pressure, and meets all needs is shown in the diagram.

The coupling is a section of pipe two or three times as long as the diameter of the line, and enough larger in inside diameter to provide a ⅛-in. to 3/16-in. annular space, which is packed at the center with oakum and filled at the ends with Smooth-On No. 1. The Smooth-On is tightly caulked, and when metallized makes a joint that is as solid as standard construction.

For a hurry job this scheme can't be beat. For instance, a steam line in the Pittsburg, Kansas, central heating system tore itself out of 8-in. flanges due to the slipping of an anchor block. The broken flanges were removed, and as the pipe could not be gotten back, a cast iron sleeve was slipped on and caulked with Smooth-On No. 1. Steam was turned on again the same day, thereby saving customers much discomfort as the accident happened in very cold weather.

Remember this when you have to make a hurried joint between broken or cut-off ends of cast-iron pipe, or where you can't get threading tools for wrought iron pipe—and be sure to have the emergency supply of Smooth-On No. 1 on hand.

Get your SMOOTH-ON *No. 1 in 1-lb., 5-lb. or 10-lb. cans from your supply house or if necessary from us direct. Write to us for free copy of the* SMOOTH-ON *Handbook, which is filled with money-saving hints that will help any engineer.*

1-28

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- ☐ Repairing cracked plates and castings.
- ☐ Patching boiler and engine cylinders.
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- ☐ Making seams tight at bolts or rivets.
- ☐ Repairing chimneys and smoke-stacks.
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P. P. Eng. 12-15 .....

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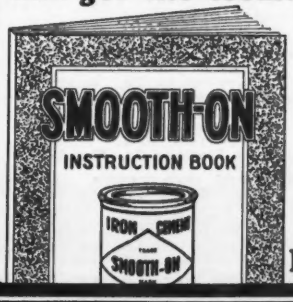

THIS 144-page book of simple directions and diagrams will post you well on the theory of Smooth-On, where to use each grade, how to apply for best results and what to expect from the finished job, based upon pictures and data from over 100 typical applications.

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FURNACES.
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Garlock Packing Co., Palmyra, N. Y.
Power Specialty Co., New York.
Quaker City Rubber Co., Phila.
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United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.
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Lonergan Co., J. E., Phila.
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Sherwood Mfg. Co., Buffalo.
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Libbey Glass Mfg. Co., The, Toledo, Ohio.
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Bailey Meter Co., Cleveland, O.
Bristol Co., The, Waterbury, Conn.
Foxboro Co., Inc., The, Foxboro, Mass.
Huyette Co., Inc., The Paul B., Philadelphia.
Pierce Co., The Wm. B., Buffalo.
Uehling Instrument Co., Paterson, N. J.
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Foxboro Co., Inc., The, Foxboro, Mass.
GAUGES, PRESSURE & RECORDING.
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Bacharach Ind. Instrument Co., Pittsburgh, Pa.
Bristol Co., The, Waterbury, Conn.
Brown Instrument Co., The, Philadelphia, Pa.
Foxboro Co., Inc., The, Foxboro, Mass.
Lonergan Co., J. E., Phila.
Republic Flow Meters Co., Chicago, Ill.
GAUGES, WATER,
Huyette Co., Inc., The, Paul B., Philadelphia.
Lonergan Co., J. E., Phila.
Penberthy Injector Co., Detroit.
Reliance Gauge Column Co., Cleveland, Ohio.
GAUGE TESTERS.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Ashton Valve Co., Boston, Mass.
Fisher Governor Co., The, Marshalltown, Iowa.
GEARS, REDUCTION.
Moore Steam Turbine Corp., Wellsville, N. Y.
GENERATING SETS.
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Carling Turbine Blower Co., Worcester, Mass.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
General Electric Co., Schenectady, N. Y.
Kerr Turbine Co., Wellsville, N. Y.
Moore Steam Turbine Corp., Philadelphia, Pa.
Terry Steam Turbine Co., Hartford, Conn.
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Kerr Turbine Co., Wellsville, N. Y.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
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Atlas Valve Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., The, Pittsburgh.
Cleveland Feed Water Regulator Co., The, Cleveland.
Davis Regulator Co., G. M., Chicago, Ill.
Dean Bros. Co., Indianapolis.
d'Este Co., Julian, Boston.
Fisher Governor Co., The, Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Mason Regulator Co., Boston.
Northern Equip. Co., Erie, Pa.
"S-C" Regulator Mfg. Co., The, Fostoria, Ohio.
Squires Co., The C. E., Cleveland.
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Watson & McDaniel Co., Phila.
Wright - Austin Co., Detroit.
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GRATE BARS.
Flynn & Emrich Co., Baltimore.
GRATES.
Babcock & Wilcox Co., The, N. Y.
Flynn & Emrich Co., Baltimore.
Hofft Co., The M. A., Indianapolis, Ind.
Kelly Foundry & Mach. Co., Goshen, Ind.
McClave-Brooks Co., Scranton.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Neemes F'dry, Inc., Troy, N. Y.
GRATES, CHAIN.
Babcock & Wilcox Co., The, N. Y.
GRATING, STEEL
Irving Iron Works Co., Long Island City, N. Y.
GRATINGS, VENTILATION
Irving Iron Works Co., Long Island City, N. Y.
GREASE.
Cook's Sons, Inc., Adam, New York, N. Y.
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Harris Oil Company, The A. W., Providence, R. I.
Keystone Lubricating Co., Phila.
Ohio Grease Co., Loudonville, O.
Standard Oil Co., (Indiana), Chicago, Ill.
Tide Water Oil Sales Corp., New York, N. Y.
Vacuum Oil Co., New York.
GREASE CUPS.
(See Oil and Grease Cups.)
GREASE CUPS, COMPRESSED AIR.
Hunter Pressed Steel Co., Lansdale, Pa.
GREASE GUNS.
Hunter Pressed Steel Co., Lansdale, Pa.
HAND STOKERS, HOPPER-FEED.
McClave-Brooks Co., Scranton.
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Power Specialty Co., New York, N. Y.
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Patterson-Kelley, New York.
Powers Regulator Co., Chicago.
Ross Heater & Mfg. Co., Buffalo.
Standard Water Systems Co. of N. J., Hampton, N. J.
HEATERS, OIL.
Griscom-Russell Co., New York.
Power Specialty Co., New York.
Ross Heater & Mfg. Co., Buffalo.
Standard Water Systems Co. of N. J., Hampton, N. J.
HOISTS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
HOISTS, SKIP.
Beaumont Mfg. Co., Philadelphia, Pa.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
HOPPERS.
Combustion Engineering Corp., New York, N. Y.
HOPPERS, COAL AND ASH.
Allen-Sherman-Hoff Co., The, Wellsville, N. Y.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago, Ill.
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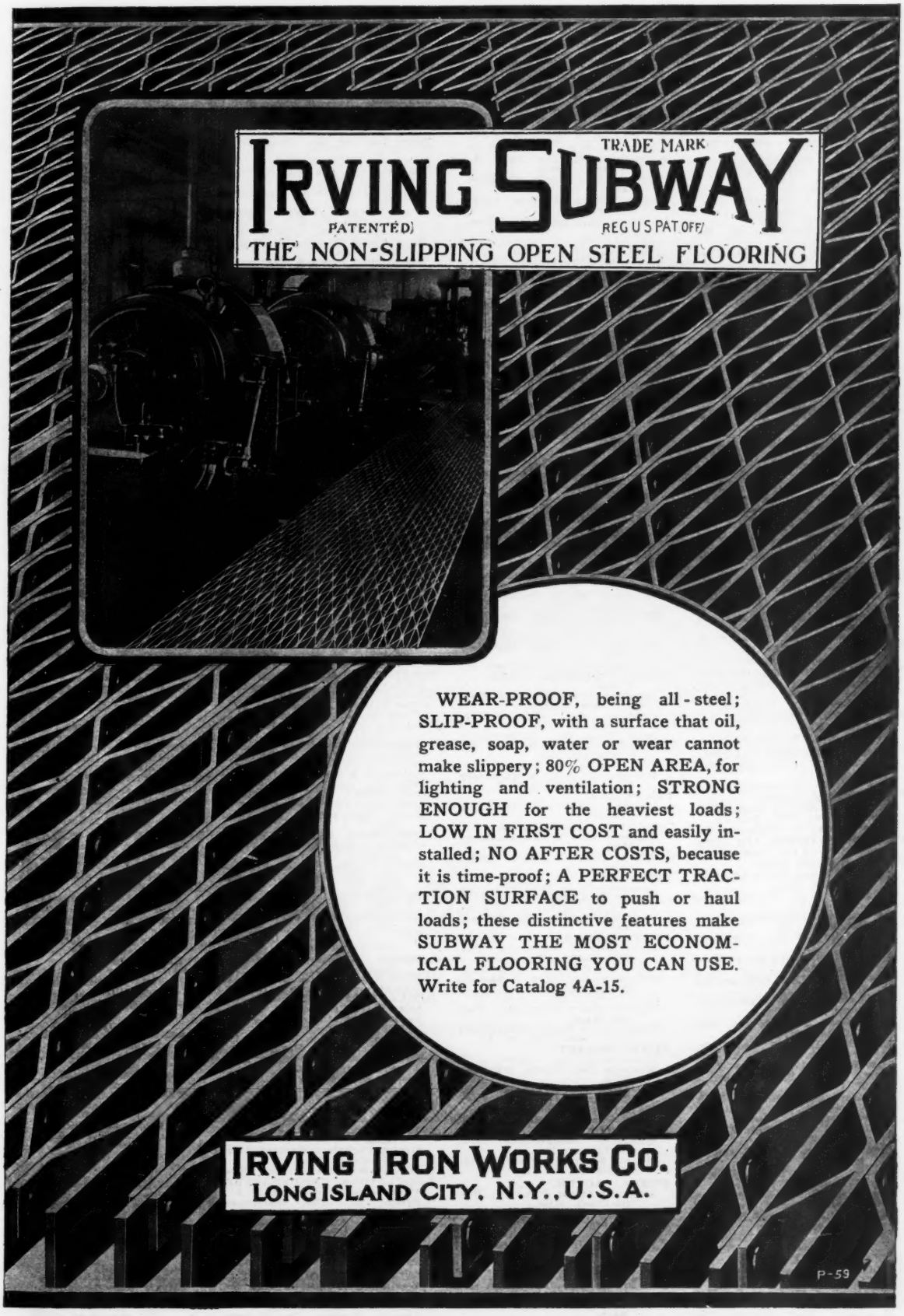
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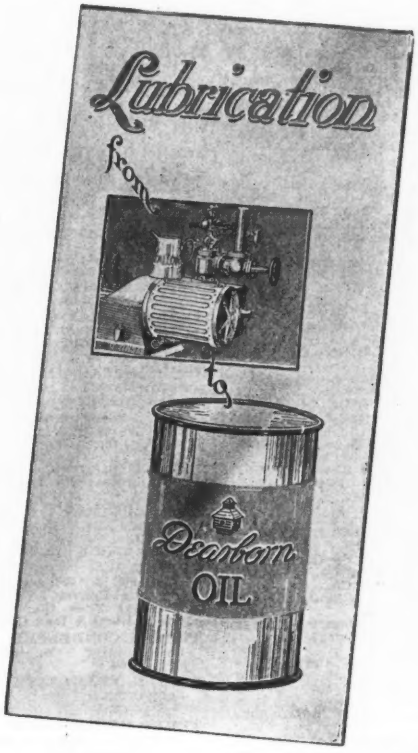

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Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Gibby Engineering Co., E. Boston, Mass.
Hoftt Co., The M. A., Indianapolis, Ind.
McClave-Brooks Co., Scranton.
Riley Stoker Co., Sanford, Worcester, Mass.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.

STOKERS, OVERFEED AND UNDERFEED.
Combustion Eng'r'g Corp., N. Y.
Detroit Stoker Co., Detroit.
Laclede Stoker Co., St. Louis.
Riley Stoker Co., Sanford, Worcester, Mass.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

STRAINERS.
Blackburn-Smith Corp., The, New York, N. Y.
Davis Regulator Co., G. M., Chicago.
Dean Bros. Co., Indianapolis, Ind.
Elliott Company, Jeannette, Pa.
Foster Engineering Co., Newark, N. J.
Ross Heater & Mfg. Co., Buffalo, Sarco Co., Inc., New York.

STRAINERS, OIL.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Blackburn-Smith Corp., The, New York, N. Y.
Elliott Co., Jeannette, Pa.
Griscom-Russell Co., New York.
Ross Heater & Mfg. Co., Buffalo, Sarco Co., Inc., New York.

SUPERHEATERS, STEAM.
Babcock & Wilcox Co., The, New York.
Badenhausen Corporation, Philadelphia, Pa.
Power Specialty Co., New York.
Superheater Co., The, New York.

SWITCHBOARDS.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

SWITCHBOARDS, ASBESTOS
Johns-Manville, Inc., New York.

TACHOMETERS.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury, Conn.
Brown Instrument Co., The, Philadelphia, Pa.
Foxboro Co., Inc., The, Foxboro, Mass.

TANKS.
Brady Conveyors Corp., Chicago,
Cochrane Corp., Philadelphia,
Conveyors Corp. of Amer., Chicago.
Sims Co., The, Erie, Pa.
Standard Water Systems Co. of N. J., Hampton, N. J.
Wright - Austin Co., Detroit.

TANKS, COPPER.
Hercules Float Wks., Springfield, Mass.

TELESCOPIC OILERS
Wm. W. Nugent Co., Chicago, Ill.

THERMOMETERS.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Ashton Valve Co., Boston, Mass.
Bristol Co., The, Waterbury, Conn.
Brown Instrument Co., The, Philadelphia, Pa.
National Regulator Co., Chicago.
Power Specialty Co., New York.
Powers Regulator Co., The, Chicago, Ill.

THERMOMETERS, RECORDING AND INDICATING.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury, Conn.
Brown Instrument Co., The, Philadelphia, Pa.
Foxboro Co., Inc., The, Foxboro, Mass.
Leeds & Northrup Co., Philadelphia, Pa.
Sarco Co., Inc., New York.

TOOLS AND SUPPLIES.
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
Rogers Co., H. A., New York.

TRAMWAYS.
American Steel & Wire Co., Chicago-New York.

TRANSFORMERS AND CONVERTERS.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

TRANSMISSION ROPE.
American Steel & Wire Co., Chicago-New York.

TRAPS, COMPRESSED AIR.
Armstrong Machine Wks., Three Rivers, Mich.

TRAPS, RADIATOR.
Armstrong Machine Wks., Three Rivers, Mich.
Sarco Co., Inc., New York.

TRAPS, STEAM AND RADIATOR
Johns-Manville, Inc., New York.

TRAPS, VACUUM.
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua, N. H.
Stickle Steam Specialties Co., Indianapolis, Ind.
Wright - Austin Co., Detroit.

TUBE CUTTERS.
Lagonda Mfg. Co., Springfield, Ohio.
Scully Steel & Iron Co., Chicago.

TUBING.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

TUBING, CONDENSER.
Scovill Mfg. Co., Waterbury, Conn.

TUBING, SEAMLESS BRASS.
Scovill Mfg. Co., Waterbury, Conn.

TURBO GENERATORS
Ridgway Dynamo & Engine Co., Ridgway, Pa.

UNDERGROUND HEATING SYSTEM.
Johns-Manville, Inc., N. Y.

UNIONS.
Atlas Valve Co., Newark, N. J.
Dart Mfg. Co., E. M., Providence, R. I.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Kelly & Jones Co., The, Greensburg, Pa.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVE DISCS.
Garlock Packing Co., Palmyra, N. Y.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

VALVE RESEATING MACHINES.
Leavitt Machine Co., Orange, Mass.

VALVES.
Atlas Valve Co., Newark, N. J.
Foster Engineering Co., Newark, N. J.

VALVES, AUTOMATIC CUT-OFF.
Elliott Co., Jeannette, Pa.
Fisher Governor Co., The, Marshalltown, Iowa.

VALVES, AUTOMATIC STOP AND CHECK.
Davis Regulator Co., G. M., Chicago, Ill.
Foster Engineering Co., Newark, N. J.
Jenkins Bros., New York.
Reading Steel Casting Co., Inc., Bridgeport, Conn.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

VALVES, BALL.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVES, BLOW-OFF.
Amco Sales Corp., Chicago.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Elliott Company, Jeannette, Pa.
Homestead Valve Mfg. Co., Homestead, Pa.
Jenkins Bros., New York, N. Y.
Lunkenheimer Co., Cincinnati, O.
Powell Co., Wm., Cincinnati, O.
Schiller Valve Co., Jos. F., Philadelphia, Pa.
Scully Steel & Iron Co., Chicago.
Williams Valve Co., D. T., Cincinnati, Ohio.
Yarnall-Waring Co., Philadelphia, Pa.

VALVES, BY-PASS.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Mason Regulator Co., Boston.
Pittsburgh Valve, Fdry. & Const. Co., Pittsburgh Pa.
Powell Co., Wm., Cincinnati, O.
Schiller Valve Co., Jos. F., Philadelphia, Pa.
Scully Steel & Iron Co., Chicago.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVES, CHECK.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Lunkenheimer Co., Cincinnati.
Pittsburgh Valve, Fdry. & Const. Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati, O.
Reading Steel Casting Co., Inc., Bridgeport, Conn.
Schutte & Koerting Co., Phila.

VALVES, FLOAT.
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., The, Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Mason Regulator Co., Boston.
Yarnall-Waring Co., Philadelphia, Pa.

VALVES, GAS.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

VALVES, GATE.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Lunkenheimer Co., Cincinnati, Ohio.
Pittsburgh Valve, Fdry. & Const. Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati, O.

VALVES, GLOBE.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Jenkins Bros., New York, N. Y.
Kelly & Jones Co., The, Greensburg, Pa.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Lunkenheimer Co., Cincinnati.
Pittsburgh Valve, Fdy. & Const. Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati, O.

VALVES, HYDRAULIC.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Homestead Valve Mfg. Co., Homestead, Pa.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading Steel Casting Co., Inc., Bridgeport, Conn.
Yarnall-Waring Co., Philadelphia, Pa.

VALVES, NON-RETURN.
Davis Regulator Co., G. M., Chicago, Ill.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Elliott Co., Jeannette, Pa.
Foster Engineering Co., Newark, N. J.
Lunkenheimer Co., Cincinnati, Ohio.

VALVES, POP SAFETY.
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Ashton Valve Co., Boston, Mass.
Lonergan Co. J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati, Ohio.

VALVES, PUMP.
Birch Mfg. Co., Chicago, Ill.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Fisher Governor Co., The, Marshalltown, Iowa.
Garlock Packing Co., Palmyra, N. Y.
Jenkins Bros., New York, N. Y.
Quaker City Rubber Co., Phila
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

VALVES, RADIATOR.
Jenkins Bros., New York, N. Y.
Powell Co., Wm., Cincinnati, O.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

VALVES, REDUCING.
Atlas Valve Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., Pittsburgh, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston.
Elliott Company, Jeannette, Pa.
Fisher Governor Co., The, Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Mason Regulator Co., Boston.
National Regulator Co., Chicago.
Powers Regulator Co., Chicago.
Squires Co., C. E., Cleveland, O.
Watson & McDaniel Co., Phila.

VALVES, REGRINDING.
Mason Regulator Co., Boston.
Penberthy Injector Co., Detroit, Mich.
Reading Steel Casting Co., Inc., Bridgeport, Conn.

VALVES, REGULATING.
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago.
Foster Engineering Co., Newark, N. J.
Powers Regulator Co., The, Chicago, Ill.
"S-C" Regulator Mfg. Co., The, Fostoria, Ohio.

VALVES, RELIEF.
Cochrane Corp., Philadelphia, Pa.
Davis Regulator Co., G. M., Chicago, Ill.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Fisher Governor Co., The, Marshalltown, Iowa.
Foster Engineering Co., Newark, N. J.
Lonergan Co., J. E., Phila., Pa.
Mason Regulator Co., Boston.
Schutte & Koerting Co., Phila.

VALVES, RUBBER.
Garlock Packing Co., Palmyra, N. Y.
Quaker City Rubber Co., Phila.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

VALVES, SIGHT FEED
Wm. W. Nugent & Co., Chicago, Ill.

VALVES, STOP.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Schutte & Koerting Co., Phila.

VENTILATING APPARATUS.
Badger & Sons Co., E. B., Boston, Mass.
Burt Mfg. Co., The, Akron, O.
Coppus Engineering Corp., Worcester, Mass.
Sturtevant Co., B. F., Hyde Park, Boston, Mass.
Wing Mfg. Co., L. J., New York.

WALKWAYS, OPEN STEEL
Irving Iron Works Co., Long Island City, N. Y.

WATER COLUMNS AND ALARMS.
Lunkenheimer Co., Cincinnati, Ohio.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright - Austin Co., Detroit, Mich.

WATER COOLING EQUIPMENT.
Cooling Tower Co., Inc., The, New York.

WATER METERS.
Bailey Meter Co., Cleveland.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago, Ill.

WATER PURIFYING APPARATUS.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.

WATER SOFTENING SYSTEMS.
Cochrane Corp., Philadelphia.
Dearborn Chemical Co., Chicago.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.

WELDING APPARATUS.
General Electric Co., Schenectady, N. Y.

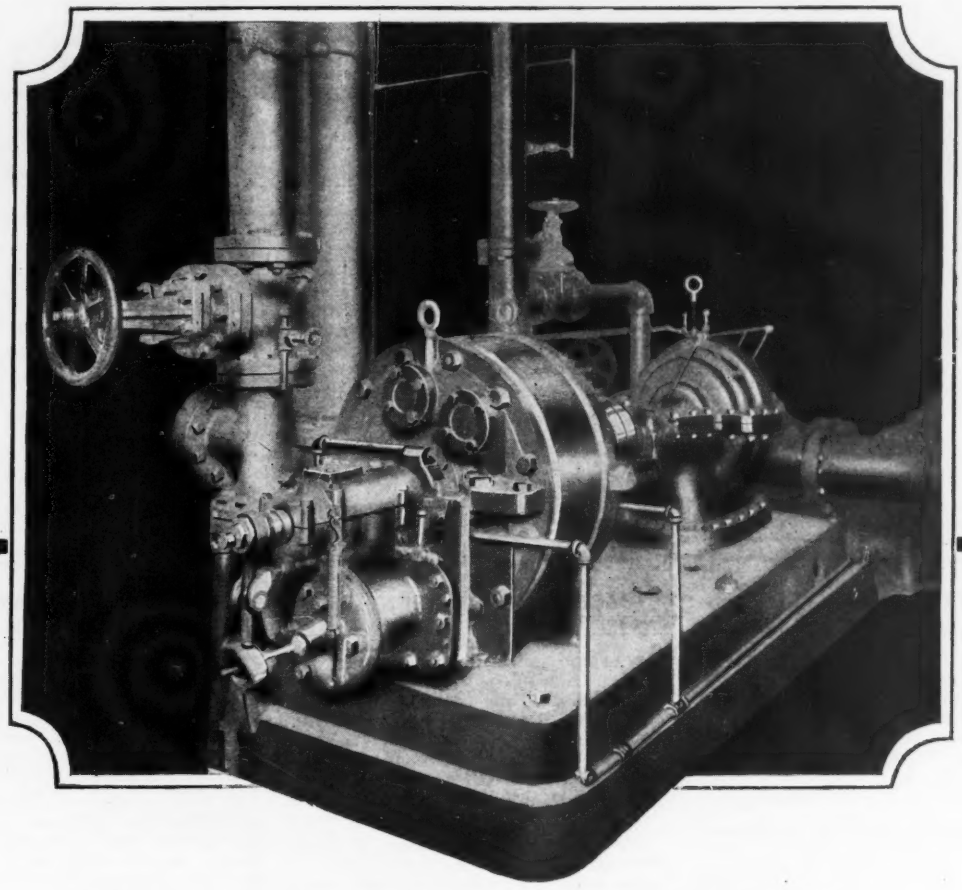
WHISTLES.
Ashton Valve Co., Boston, Mass.
Lonergan Co., J. E., Phila., Pa.
Powell Co., Wm., Cincinnati, O.

WIRE BRUSHES.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

WIRE OF EVERY DESCRIPTION.
American Steel & Wire Co., Chicago-New York.

WIRE ROPE AND FITTINGS.
American Steel & Wire Co., Chicago-New York.

WRENCHES.
Strong, Carlisle & Hammond Co., Cleveland, O.



Kerr Turbine Reliability

A Safeguard against Flooding at the Corn Products Refining Co.

Two 2-stage centrifugal sump pumps at the Argo, Ill., plant of this company are driven by Kerr Turbines, operating non-condensing. The clean exhaust steam is available for feed water heating, process work and heating the buildings.

While the service is of an intermittent nature, it is absolutely essential that these pumps will operate when the demand occurs. The KERR TURBINE drive secures the maximum dependability.

Since their installation over three years ago, there has been no repair expense on the turbines.

For all power requirements in units up to 2,000 k.w. capacity, your safe choice will rest on KERR TURBINES. They are made for high, low and mixed pressure, condensing, non-condensing and bleeder types.

Write Us for Bulletin Now

KERR STEAM TURBINES-REDUCTION GEARS
KERR TURBINE COMPANY
WELLSVILLE, NEW YORK U·S·A·

DISTRICT OFFICE ALL LARGE CITIES

SIGNBOARD SECTION

Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classification "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Business Opportunities," "Patent and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

50 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

For display of any advertisement under the above classified headings see sizes and rates in column at right.

DISPLAY RATES

Advertisements in Signboard Section which come under the classification "Equipment for Sale," "Equipment Wanted," "Educational and Instruction" and "Miscellaneous" are set in display space of the following sizes and at these rates:

1 in.	$ 5.50	4 in.	$20.80
2 in.	10.80	1 col. (8½ in.)	43.35
3 in.	15.90	2 col. (17 in.)	85.00

Not less than one inch to be sold in these classifications.

For advertising rates under other headings in this section, see column at left.

POSITIONS WANTED

POSITION WANTED by engineer with 18 years' experience with turbines, generators, reciprocating steam engines, refrigeration and erecting. Central states preferred. Address Box 812, Power Plant Engineering, 537 So. Dearborn St., Chicago, Ill.

DESIRES CHANGE—Engineer 30 years of age, and married, who has had eleven years experience in the operation and repair of both industrial and public utility power plants, together with technical training as follows: I. C. S. Steam-Electric Course and Hays Institute Course in Fuel and Combustion Engineering. Address Box 813 — Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

POSITION WANTED—As chief engineer and all around fireman. Can repair boilers, steam pipe fittings, steam or water dynamo. Maintenance A. C. or D. C. Electrical graduate. Have diploma for both steam combustion and electricity. Have 30 years experience and can save money in plant operation. First class references. W. C. Siple, Box 385 Carson City, Mich.

POSITION WANTED — Engineer, 12 years' experience operating and maintaining of steam turbines, Corliss engines, water tube boilers, electrical equipment; technical education; employed; married; West preferred; best of reference. Address Box 810, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

SALESMEN AND AGENCIES

WANTED — Salesmen experienced in Boiler Room supplies, to handle "REX" Boiler Treatment. Commission Basis. State age, experience, territory covered. Address, Sales Manager, 228 N. 13th St., Lincoln, Nebraska.

SALESMEN AND AGENCIES

WANTED—Sales agents: Refractory cements and plastic fire brick accounts. United States and Canada. Hustlers make good commissions. Reliable agents offered attractive carload arrangements. Full protection. If interested address The S. Obermayer Company, 2563 West 18th St., Chicago, Ill.

WANTED—Sales Engineers. We have lines exclusively for the boiler room and want some live connections for territories open. If you are established and want additional lines, address Box 816, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

The Girtanner Engineering Corporation, 1400 Broadway, New York City, manufacturers of the well known Steam Jet Ash Conveyors, have extended their line to include Water Ejectors, Soot and Pulverized Coal Ash Conveyors and Fire Brick Grinding Machines, desire representatives in various sections. Write for information on open territory.

EDUCATIONAL AND INSTRUCTION

INVENTORS' Educator: 900 Mechanical Movements. 50 Perpetual Motions. How to procure and sell patents. Mechanical Movements greatly assist Inventors, suggest new ideas. Explains how to select an attorney and avoid Patent Sharks. Price, $1.50. Postage Free. Albert E. Dieterich, 160 Ouray Building, Washington, D. C. tf

PATENTS AND PATENT ATTORNEYS

PATENTS.—Write for my free Guide Books "How to Obtain a Patent" and "Invention and Industry" and "Record of Invention" blank before disclosing inventions. Send model or sketch of your invention for instructions. Promptness assured. No charge for above information. Clarence A. O'Brien, Registered Patent Lawyer, 231-C Security Bank Building, directly across street from Patent Office, Washington, D. C.

PATENTS AND PATENT ATTORNEYS

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C., Established 1883. I make an examination and report if a patent can be had and the exact cost. Send for full information. tf

A. P. CONNOR, Consulting Electrical and Mechanical Engineer. Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf

PATENTS PROCURED; TRADE MARKS REGISTERED — A comprehensive, experienced, prompt service for the protection and development of your ideas. Preliminary advice gladly furnished without charge. Booklet of information and form for disclosing idea free on request. RICHARD B. OWEN, 28 Owen Bldg., Washington, D. C., or 41-P Park Row, New York City.

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Patents obtained and Trade-Marks registered in the United States and foreign countries. Patent practice exclusively in Patent Office and Courts. Examinations made and opinions rendered as to patentability of inventions, and validity, scope and infringement of patents. Highest references.

Watson E. Coleman, Patent Lawyer
644 G Street Washington, D. C.

Patents TRADE-MARKS, COPYRIGHTS AND PATENT LITIGATION

Write for advice and instructions how to proceed, costs, etc. Hand Book with illustrations of 100 Mechanical Movements sent free on request. ALBERT E. DIETERICH
Patent Lawyer and Solicitor
Successor to Fred G. Dieterich & Co.
160A Ouray Bldg. WASHINGTON, D.C.

PROFESSIONAL CARD

Sessions Engineering Co., Inc.
ENGINEERS and CONSTRUCTORS
STEAM, ELECTRIC, HYDRO AND INDUSTRIAL PLANTS
APPRAISALS, SURVEYS AND REPORTS
208 South LaSalle St. Chicago
Western District Office, Portland, Ore.

SIGNBOARD SECTION

Quick Action Opportunities

EQUIPMENT WANTED

Water-Works Pump Wanted

We are in the market for a good used Steam Driven Waterworks Pump (Crank and Flywheel Type preferred), capacity 750 to 1000 Gal. per minute and capable of developing 100 lbs. water pressure. Give full description and best cash price in first letter.

Marysville Light & Water Co.
Marysville, Ohio

WANTED—High class turbine or high speed engine 100 to 150 H.P. Direct connected to D.C. 125-volt generator. Must be guaranteed to be in good condition. **Prompt delivery for cash. Address:**

DR. MILES MEDICAL COMPANY
ELKHART, IND.

We Will Buy
Your Surplus
PIPE COUPLINGS
We pay highest prices.
Small and large lots accepted.
Submit list.
H. C. ATKINS MFG. CO.
744 S. 3rd St. St. Louis, Mo.

A Signboard Seen *from* Coast *to* Coast

If you are engaged in the power field and have a piece of equipment to sell, an engine, a motor, boiler, compressor, belt, or anything that is used in power plants and which you have laid aside, at a single stroke you can put your selling message where it will be seen, and read from coast to coast.

More than 21,000 power plant operators focus their eyes on this SIGNBOARD twice a month, looking for the things they need for their plants.

Not only is second-hand machinery sold and bought through the words blazoned here, but first-class men are found for every power plant opening.

The cost of displaying a message on this great Signboard is less than the cost of writing to even two or three hundred of the engineers who need it.

This Signboard is seen from coast to coast. It is the Signboard Section of Power Plant Engineering.

Write Your Message on It

EQUIPMENT FOR SALE

Power Machinery Exchange

1 Montgomery Street, Jersey City, N.J.

A. C. Units

3-Phase 60-Cycle

Kva.	Generator	Engine
625	Westghse.	Parsons Turbine (Bleeder)
500	Gen. Elec.	Curtis Turbine
475	Gen. Elec.	Skinner Unaflow
470	Westghse.	Parsons Turbine
360	Gen. Elec.	Harris Corliss
312	Gen. Elec.	Skinner Unaflow
250	Al. Chal.	Al. Chal. Corliss
250	Gen. Elec.	Skinner Unaflow
250	Gen. Elec.	Erie Ball 4 Valve
200	Al. Chal.	Al. Chal. Corliss
187	Gen. Elec.	Erie 4 Valve
150	Al. Chal.	Al. Chal. Corliss
125	Gen. Elec.	Harrisburg 4 Valve
129	Gen. Elec.	Erie City 4 Valve
129	Gen. Elec.	Erie Ball 4 Valve
100	Gen. Elec.	Skinner
90	Gen. Elec.	Skinner Unaflow
90	Gen. Elec.	Ames Unaflow
75	Gen. Elec.	Skinner
70	Westghse.	Harrisburg
50	Gen. Elec.	Skinner

A. C. Generators

Kva.	Make	Speed
500	Gen. Elec. (3 Brg.)	360
500	Gen. Elec. (3 Brg.)	360
412	Al. Chal. (3 Brg.)	450
400	Gen. Elec. (3 Brg.)	360
360	Westghse. (3 Brg.)	360
300	Gen. Elec. (3 Brg.)	450
300	Al. Chal. (3 Brg.)	600
250	Westghse.	600
225	Gen. Elec.	600
200	Westghse.	450
200	Gen. Elec.	600
187	Al. Chal.	600
150	Al. Chal.	900
150	Westghse.	450
125	Gen. Elec.	600
100	Al. Chal.	900
75	Gen. Elec.	1200
56	Gen. Elec.	1200

Boilers

2—315 Stirling Water Tube 180 lb. pressure with Jones Stokers complete, $8 per Hp. F. O. B. Battle Creek, Mich.

Boilers, Engines, Motors and Generators—All sizes. Write for information.

For Quick Sale 75% Off

No Reasonable Offer Refused

1—Improved Greene Engine 25"x48" in good condition.
1—Improved Greene Engine 22¾"x42" in good condition.
1—Wetherill Corliss Engine 25"x48".
1—Watts-Campbell Corliss Engine 23"x48", now in operation.
4—Wickes Vertical Boilers 110 pounds pressure. Fair condition.
1—60 kw. Westinghouse 2 phase, 220 v, 60 cycle, Generator with exciter.

Certain-Teed Products Corp.
2nd and Erie Ave., Philadelphia, Pa.

BARGAIN

Slow speed motors. 2 200 H. P. New 235 R. P. M Westinghouse Electric Motors at fraction of original cost.

STANDARD ELEC. MACH'Y CO.
9 E. Hill St., Baltimore, Md.

FOR SALE—CORLISS ENGINE

16 x 36—150 horse power C & G Cooper Corliss Engine good condition. Will sell cheap as we need the room.

Shelby Spring Hinge Company
Shelby, Ohio

Equipment for Complete

3600 Horsepower Boiler Plant

Consisting of

1—500 Horsepower Edge Moor boiler, 200 lbs. pressure.
10—316 Horsepower Heine boilers, 150 lbs. pressure.
3—300 G.P.M. turbine driven centrifugal boiler feed pumps; head 165 lbs.
14x36, in fair condition. One Triumph
1—4000 Horsepower Webster open feed water heater with oil separator.
1—4000 Horsepower Cochrane V-notch Meter.
1—42"x11'-0" riveted blowoff tank.
1—Sturtevant No. 6 double width Multivane Blower, and Coal and ash conveyors, piping, steel plate flue and drip pumps with receivers.

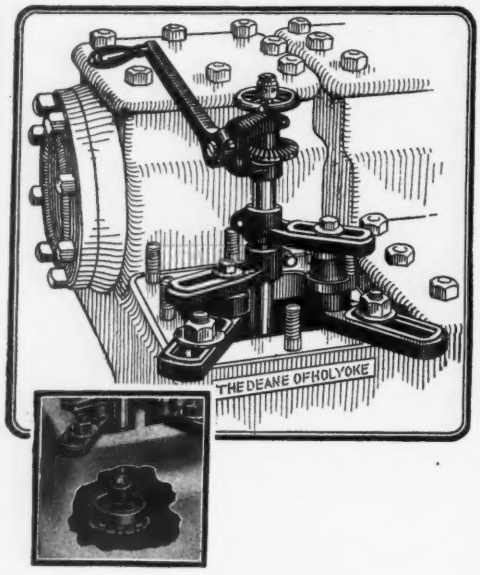
Now in daily service. Available January 1, 1925.
Will be sold as a whole or individual units, with necessary valves and fittings for each unit. Complete specifications upon application.

Victor Talking Machine Co.
Camden, New Jersey

For Sale

One Lane & Bradley Corliss engine 14x36, in fair condition. One Triumph Generator, exciter with belt and switchboard panel; one 100 h.p. Brownell boiler in fair condition.

City of McLeansboro, Ill.



How to Fix Leaky Pumps

Racing, power-wasting pumps are no longer tolerated in plants striving for operating economy. It is too easy and inexpensive to keep every pump at top-notch efficiency by refacing the valve seats with a Dexter Pump Valve Reseating Machine.

The Dexter Machine is quickly bolted to the studs of the valve chamber. Cutters are automatically self-leveling. A few turns of the handle, turning feed wheel slowly, and the valve seat is perfectly true and smooth. Pump strokage is reduced 40 to 80 per cent.

Look over the pumps in your plant. Wouldn't it be worth while to keep their steam consumption at a minimum, lessen depreciation and maintain full pumping capacity? The saving will pay for a Dexter Outfit many times over.

Ask for Catalog 23 containing complete information.

The Leavitt Machine Company
11 East River Street, Orange, Mass., U. S. A.

Canadian Agency: Darling Bros., Ltd., 120 Prince St., Montreal

British Agency: Cromil Engineering Co., E. Floor, Milburn House, Newcastle-on-Tyne

7498

DEXTER VALVE RESEATING MACHINES

Service Points of Badger Joints

One-piece construction—no packings—leak-proof.
External equalizing rings—equally distribute expansion among all corrugations.
Easy to install as a flange fitting.
Extremely compact—less diameter than the flanges in most installations.
Write for catalogue giving all the points.

Established 1841

E. B. BADGER & SONS COMPANY
Boston, Mass.
New York Office, 101 Park Ave.

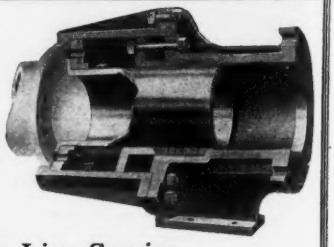
READING

EXTRA HEAVY STEEL VALVES

The valves for high temperatures and severe services
For 350 pounds working steam pressure

READING STEEL CASTING CO.
INCORPORATED
Reading Valve and Fittings Division
An Associate Company of the American Chain Company, Inc.
929 Connecticut Avenue **Bridgeport, Conn.**

Howard Guided Expansion Joint



For Pipe Line Service

Eliminates trouble from Expansion and Contraction, saves space, labor and repair bills; the construction is mechanically correct.

ALBERGER HEATER CO. **285 Chicago St.**
HOWARD IRON WORKS **Buffalo, N. Y.**

Right bang up against the wall and back of another pipe — but it's easy with No. 3 Jr.

Just like child's play to thread this pipe with No. 3 Jr. As handy as a wrench.

How to Judge Your Die Stocks!

The real test of a die stock is its ability to cut perfect threads with ease, speed and convenience, under all conditions.

And No. 3 Beaver Jr. Ratchet shown in use here is just such a tool. It threads ⅛, ¼, ⅜, ½, ¾ and 1 inch, using separate die heads. These heads are quickly changed by releasing a convenient ratchet pawl.

You can buy just the die heads you need—adding others as your work requires.

With No. 3 Beaver Jr. Ratchet you can get back into tight, cramped quarters and cut perfect threads, with ease. Most fitters use it at the bench also because of its speed and convenience, — its so handy and so easy to use.

Every leading jobber carries No. 3 Beaver Jr. in stock—likewise all other Beaver Die Stocks and Square-End Cutters from ⅛ to 12 inches.

A complete catalog of all these tools is yours for the asking.

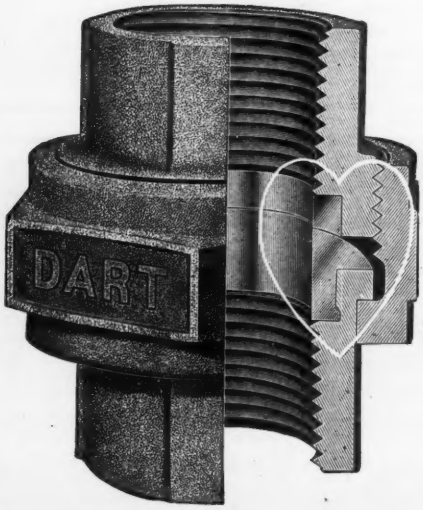
THE BORDEN COMPANY
509 Dana Ave., Warren, Ohio

BEAVER

The Easiest Way to Cut Good Threads

DART—the Buy-Word for UNIONS

Their Bronze-to-Bronze Seats Mean DOUBLE SERVICE to You

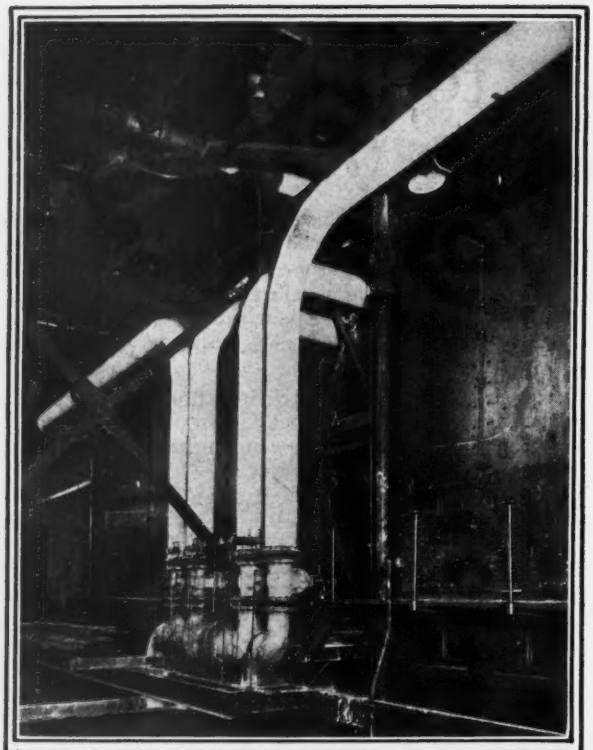


Heavy bronze rings, swedged securely into recesses **shaped to hold them**—each seat machined to form a **true arc**—then each pair ground with oil and corundum to a perfect ball joint—that's the secret of the "Heart of the Dart," the famous Bronze-to-Bronze Joint, that's leak-proof, non-corrosive, hermetically tight and gives **double the service you ordinarily expect.**

Dart—the by-word of dependability in Unions, is the BUY-WORD with engineers who know them. Write for a sample union and copy of catalogue "T."

E. M. DART MANUFACTURING CO.
Providence, R. I.

Sales Agents: The Fairbanks Co., New York, and at all branches. Canadian Factory: Dart Union Co., Ltd., Toronto, Canada.



Power Plant Piping

Furnished and installed complete for Power Plants of all kinds.

Properly conveyed steam is in itself an achievement of vital interest and importance.

When you add to this a saving in shut-down time; a saving in fuel consumption; a record for sustained efficiency, due to proper construction of joints, bends, fabrications and erection, it is not difficult to see why Pittsburgh Piping is specified, "The best in Power Plant Piping construction."

Write for information.

Pittsburgh Piping & Equipment Co.
35th and Charlotte Sts.
Pittsburgh, Pa.

NEW YORK, 220 BROADWAY. CLEVELAND, ULMER BUILDING.
CHICAGO, PEOPLES GAS BUILDING. BIRMINGHAM, AMERICAN TRUST BLDG.
SAN FRANCISCO, CALL BUILDING. INDIANAPOLIS, TRACTION TERM. BLDG.

PITTSBURGH PIPING

THE BABCOCK & WILCOX TUBE CO. TUBES

Bent Tubes *for* Stirling Boilers

The Undivided Responsibility of the builders of Stirling Boilers for their quality is impaired when replacements are made with tubes different from those used by the builders.

We furnish tubes accurately made and bent by the organization that builds the Stirling Boilers.

The Babcock & Wilcox Tube Co.
Beaver Falls, Pa.

New York, 85 Liberty St. Boston, 49 Federal St. Chicago, Marquette Bldg.
Pittsburgh, Farmers Deposit Bldg. Philadelphia, Packard Bldg.
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Cup Drawn Admiralty Mag. 75x

SCOVILL
CONDENSER TUBES *last longer*

Cup Drawn Admiralty for Salt Water
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Member of Copper and Brass Research Asso.

Mills and Factories
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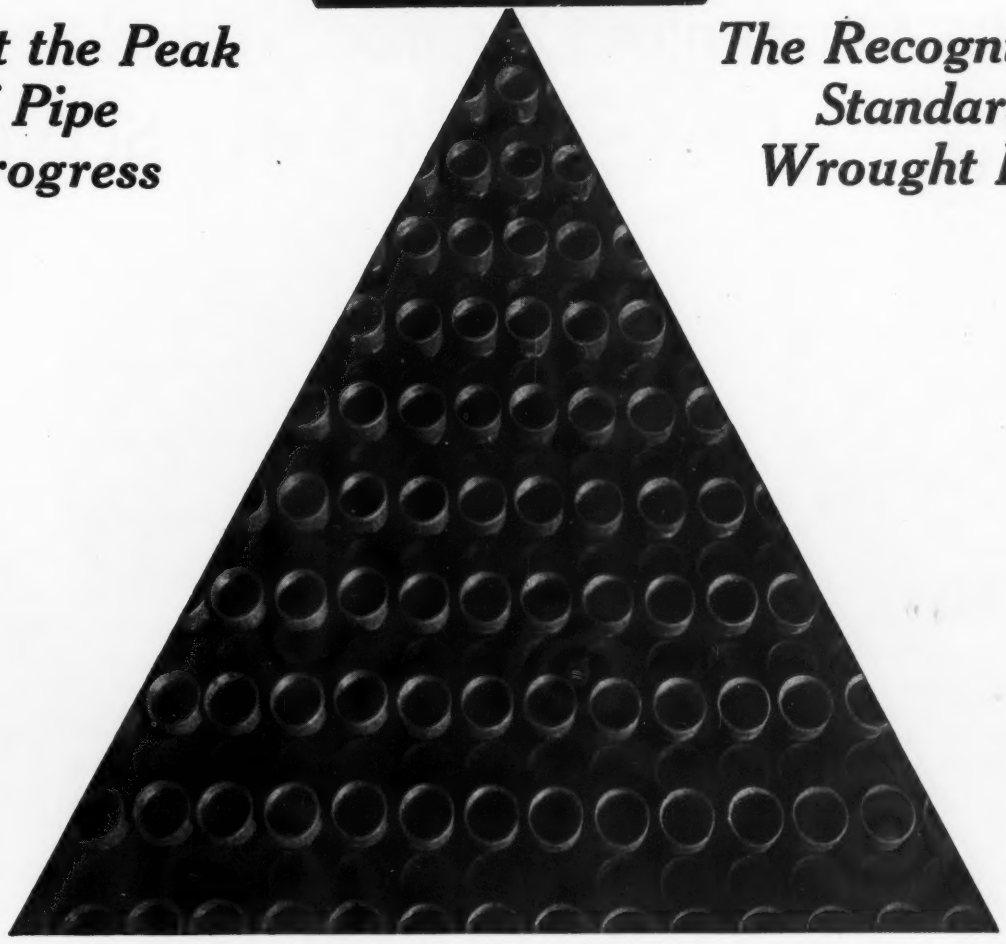
ESTABLISHED 1802
SCOVILL MANUFACTURING COMPANY

DESIGNERS AND BUILDERS
VALVES · FITTINGS AND APPLIANCES
OF EVERY DESCRIPTION
For the installation of Steam, Gas, Water, Air and Hydraulic Piping
ATWOOD ATWOOD
PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.
PITTSBURGH PA.

NATIONAL

At the Peak of Pipe Progress

The Recognized Standard of Wrought Pipe



Uniform in chemical and physical properties. Gives clean, strong threads. Sizes under 4-inch "Spellerized" to resist corrosion. Butt-weld sizes ½ to 3" made by welding-scale removing process. Made in forty-foot lengths in certain sizes. Furnished with any type of joint or plain end for couplings or welding. Particularly suitable for bending. Various protective coatings can be applied. Every length inspected and tested, and a kind, size and thickness for any power plant purpose. Ask for "National" Bulletin No. 10—"NATIONAL" Pipe for Power Plants.

NATIONAL TUBE COMPANY, PITTSBURGH, PA.

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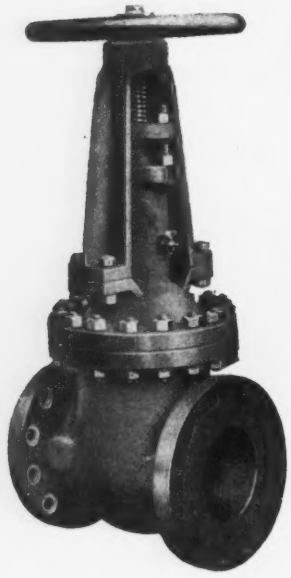
CHAPMAN

Why Chapman Chrome Nickel Steel Gives Better Valve Service



Chapman Steel Gate Valve for superheated steam. 400 lbs. working pressure, 800 degrees total temperature. Plug or wedge type. **Guaranteed for five years.**

Higher pressures and temperatures call for a better steel in valves than that used heretofore.

To meet these severe conditions with even greater safety and better service than when lower pressures were used, Chapman engineers and metallurgists have worked for years. The resulting production of Chapman Chrome Nickel Steel fully justifies all the time and expense we have given to perfecting it.

Chapman Chrome Nickel Steel is made in our own electric furnaces and is guaranteed to have the same superior physical properties and characteristics which won instant recognition when we first made it known.

Put your valves on the low-cost, high-safety, long-lived basis that others are enjoying, by specifying Chapman—the only valves using Chapman Chrome Nickel Steel.

The Chapman Valve Mfg. Co.

Indian Orchard, Mass.

BRANCHES:

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New York	Philadelphia	Detroit	Houston	Atlanta
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SPECIFY

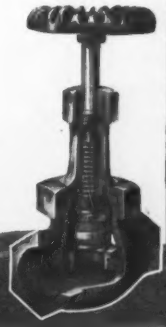
Iron Body Bronze Mounted

LUNKENHEIMER GLOBE AND ANGLE VALVES

and insist upon having the genuine. There are positively none better.

Small or large, for low or high pressures and temperatures, of Bronze, Iron Body Bronze Mounted, Steel Monel Mounted, or of "All Iron" for handling fluids which attack bronze alloys, a design particularly adapted for any service can be found in the comprehensive line of Lunkenheimer Globe and Angle Valves.

The completeness of the line makes possible standardizing on Lunkenheimer Products with that resultant prolonged satisfactory service and economy of maintenance provided only by the Lunkenheimer method of manufacture.



Write for detailed information

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LARGEST MANUFACTURERS OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD
NEW YORK CHICAGO CINCINNATI, U.S.A. BOSTON LONDON
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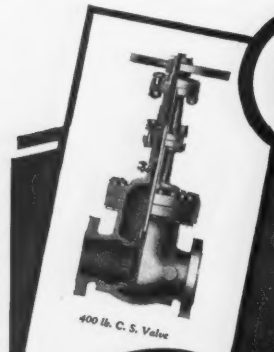
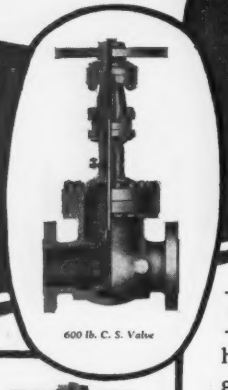
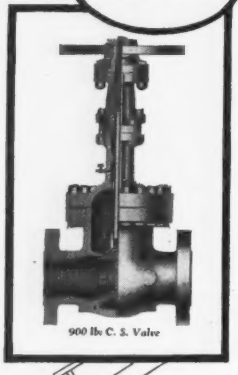
Steel Monel Mounted

"America's Best since 1862"

Bronze "Renewo"







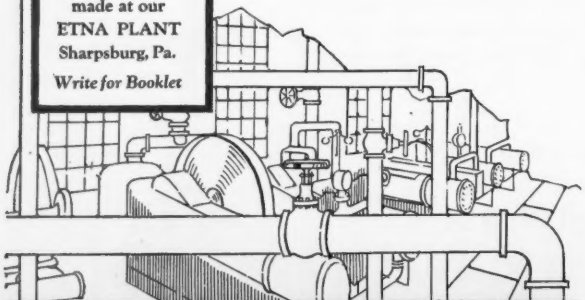
New VALVES for the Power Plant

FOR those lines where the temperature runs high, where the pressure gets up near the peak, where the maximum load puts a burden on ordinary equipment, — those are the lines that require the new K. & J. cast steel valves.

Designed for safety, dependability, and ease of operation, these cast steel valves meet every requirement of present day high pressure and high temperature power plant operation.

The line is complete, sizes ranging from ¾-in. to 24-in. and suitable for working pressures up to 900 lbs. superheated steam.

Power Plant Piping, Coils and Headers of all kinds made at our ETNA PLANT Sharpsburg, Pa. *Write for Booklet*



THE KELLY & JONES CO.

WORKS - GREENSBURG, PENNA.

BRANCH STORES AND OFFICES: NEW YORK - PITTSBURGH - CHICAGO - CINCINNATI - BUFFALO - ST. LOUIS - SAN FRANCISCO

In All Circumstances

you can depend upon

POWELL VALVES

to do the work required of them

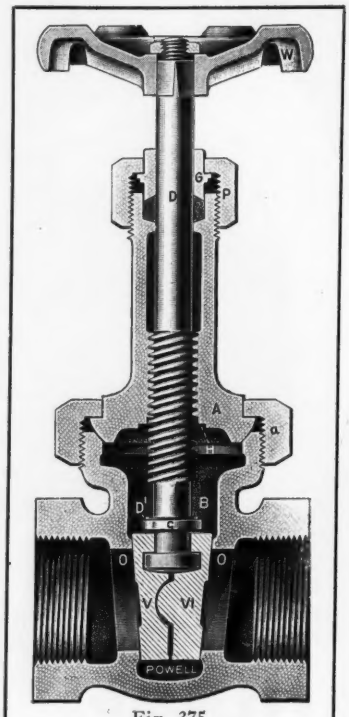


Fig. 375

White Star Gate Valves

are guaranteed to give service and satisfaction. Regular type for steam working pressure up to 200 lbs. Extra heavy type for pressure up to 300 lbs. Double wedge discs of non-corrosive white Powellium Nickel. Rising or non-rising stem. Sizes ¼ to 3 inches.

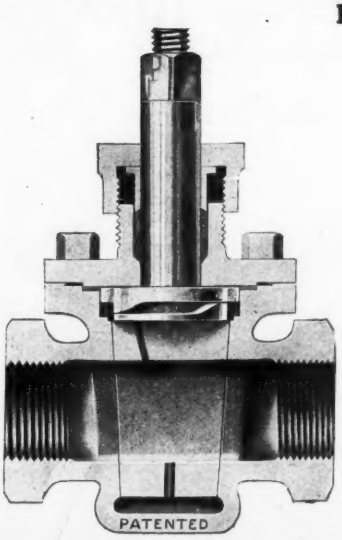
FITNESS FOR THE WORK IN HAND. Valve requirements are almost numberless and it is important that every valve installed be really adapted to the work in hand. Among the hundreds of Powell types there is a valve for every need. We are constantly perfecting new types to meet new or changing conditions.

WRITE FOR CIRCULAR

THE WM. POWELL CO.

1202 Draper Street Cincinnati, Ohio

Where you could use Homestead Quarter-Turn Valves in your power plant to your advantage



Here are some of the classes of service for which Homestead Quarter-turn Valves are used in many power plants to the advantage of operator and owners.

The following figure numbers will be found in our catalog:

1. Blow-off Valves on Boilers. Types for all pressures and conditions. Used by leading boiler manufacturers and power plants.
2. Blow-down Valves on Water Columns. Use Fig. 2, 5, 22 or 100, depending on conditions. (See cut.)
3. Fuel Oil Supply Lines. Fig. 2 or 22. (See cut.)
4. Soot Blower Lines. Live steam very troublesome service. Fig. 100 lubricated valve or Protected Seat Valve (Globe).
5. Super-Heated Steam Lines to temperature of 500 deg. Total Heat. Fig. 100 or Fig. 62 lubricated.
6. Air or hydraulic lines to boiler tube cleaners. Fig. 2 Valves.
7. Steam lines to Ash Ejectors Fig. 2 or Fig. 100.

Homestead Quarter-turn Valves give longer service because the seats are protected while the fluid is passing through the valve. They open and close quickly and easily and remain tight on most exacting service.
Thousands of users have been getting satisfactory service during the last thirty years.
Specify "Homestead" Quarter-turn Valves and watch results on your most troublesome installations.

Catalog shows the various types and sizes manufactured.

HOMESTEAD VALVE MANUFACTURING CO.
136 Sixth Ave. Homestead, Pa.

HOMESTEAD VALVES

REVERSO *cuts valve costs in half*

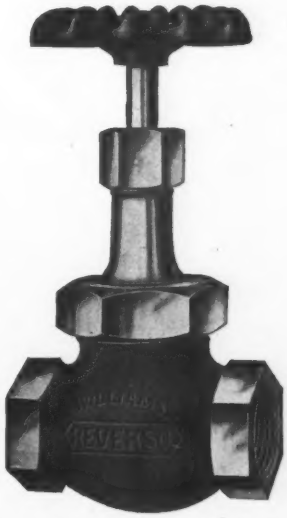
The Valve with the Reversible Disc & Seat

COSTS count in these days and the cost of a valve is by no means its first cost. Figured on the cost per year of leak-tight service, Reverso Valves win their way with the closest buyers.

Both seat and disc being easily reversible, the life of Reverso is doubled by this feature alone with no extra expense. Then each side of both the seat and disc are good for many regrindings.

Leading industries are specifying Reverso because of the unusual records they are making in economy. Engineers prefer them because of the time, trouble and repairs they save.

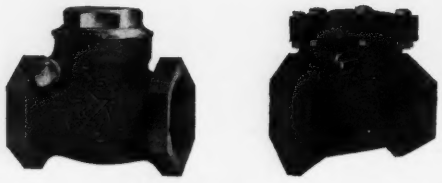
Order from your dealer and see for yourself. Write for bulletin No. 15.



The D. T. Williams Valve Co., Cincinnati, Ohio

KENNEDY

Valves for every power plant service



Check Valves

The Kennedy Check Valve line is exceptionally complete, including horizontal, swing and angle types, in bronze, iron mounted and all iron, with or without regrinding discs, in a wide range of sizes and pressures, and also including valves accepted by the Fire Underwriter Boards.

The kind of service that can be expected from Kennedy Check Valves is indicated by the experience of an Illinois electric light company, where a Kennedy Check Valve is still practically as good as new after more than fifteen years of service with water containing magnesia and grit and after replacing a valve of another make that was worn in three years.

You are safe in standardizing on Kennedy Valves, no matter what the service may be. The Kennedy line, comprising 600 different types and sizes includes the right valve for every power plant equipment. Send for catalog describing the entire Kennedy line.

THE KENNEDY VALVE MFG. CO. ELMIRA, N.Y.

Branches and Warehouses
New York: 95 John St. Boston: 47 India St.
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Sales Offices: Salt Lake City, El Paso, Seattle

(361)

The choice of the engineer

The engineer, perhaps better than any other individual, knows valves. He has used them practically all his life, under all conditions, for a variety of purposes. He realizes the stresses under which cheap valves of inferior construction fail. He also knows and appreciates at its true value the heavy valve construction that will stand up under the severest service.

This being so, it isn't at all surprising that thousands of engineers throughout the country are insisting on and using Jenkins Valves only.

Jenkins Valves have been the choice of engineers for fully sixty years. They have established a recognized reputation for careful workmanship, accurate construction, correct design, and applicability to the uses for which they are recommended. They are renowned for the long years of genuine service which only genuine Jenkins Valves give.

Valves in bronze, iron and steel, for practically all requirements. At supply houses everywhere.

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Always marked with the "Diamond"

Jenkins Valves

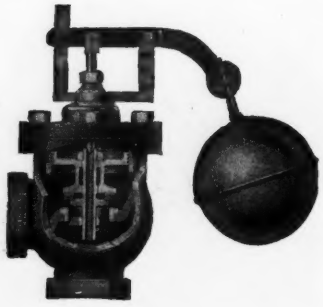
SINCE 1864

Do your float valves stick? —refuse to close tight?

THE Davis Float Valve has no leather cup packing. The inner valve is loosely fitted and cannot stick. There is no leakage from the top to run down over the body. Having a single seat with renewable composition disc, this valve closes tight.

With the Davis Float Valve the inner valve has a hollow post. It is not connected to the stem, but is operated entirely by pressure. The stem is directly connected to the float by means of a lever and forms an auxiliary valve that seats in the hollow post.

A copy of the free Davis Catalog, a regular valve handbook, should be in every engineer's possession. Got yours? Then it's waiting at the office of the G. M. Davis Regulator Co., 429 Milwaukee Ave., Chicago.



Davis:
Balanced Valves
Float Valves
Fluid Control Valves
Back Pressure Valves
Exhaust Relief Valves
Water Relief Valves
Stop and Check Valves
Steam Traps
Pump Governors
Emergency Stop Valves
Flow Regulators
Pressure Regulators
Non-Return Valves

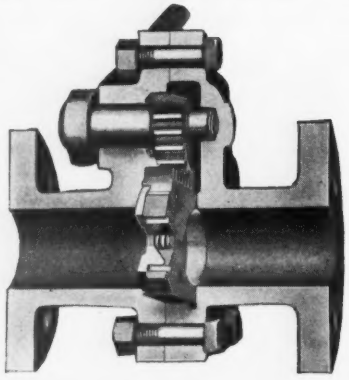
DAVIS VALVE SPECIALTIES
STEAM SAVERS SINCE 1875

PPE12-15F-RTG

YOU NEED THIS VALVE

for economical, drop-tight boiler blow-off as well as for service on steam, water, oils, acids, etc. It's the

Schiller Ever-Tight



The Schiller Ever-Tight valve is lever and gear-operated. Solid matter and fluid pass straight through without clogging or touching seat. Boiler pressure holds valve disc absolutely tight. Works easily under all pressures. Satisfaction guaranteed.

Bulletin and details of our trial offer mailed on request.

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314-320 So. Lawrence St., Philadelphia, Pa.
Direct Representation Wanted in Open Territory

Yarway Tandem Blow-Off Valve
Yarway Seatless Blow-Off Valve
Yarway Double-Tightening Valve
Yarway Involute Spray Nozzle (Klein Patents)
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Yarway Steam Trap

For literature describing any product, write to

YARWAY
YARNALL-WARING CO.
Mermaid Street
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Power Plant Devices *to save fuel*
Yarway Blow-Off Valves—Yarway Spray Nozzles—Yarway-Lea V-Notch Meters

The EDWARD Line
for all severe conditions of power plant service:
Globe and Angle Stop Valves
Check Valves
Non-Return Valves
Drum Head Stop and Check Valves
Blow-Off Valves
Atmospheric Relief Valves

EDWARD VALVES
are
Specified
by engineers responsible for the country's greatest plants.

The Edward Valve & Manufacturing Co.
East Chicago, Ind.
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Meets Every Test of Power Plant Service

The strength, permanency and reliability incorporated in the straight-way, quick-acting, easy-opening, anti-drip and leak-proof

OKADEE VALVE

eliminate blow-off troubles and enable it to meet every test of power plant service. Tested to 500 lbs. per square inch hydraulic pressure before leaving shop, and guaranteed. Used by leading power plants as well as on 65 out of every 100 of the country's locomotives.

Take advantage of our liberal **60-day Free Trial Offer.** Actual performance will prove the reliability and economy of **Okadee** service.

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The Rub-Steel Valve

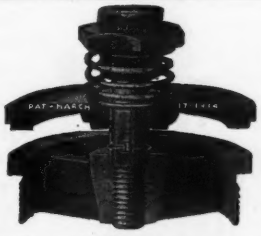
VOORHEES RUBBER MFG CO
TRADE MARK

Rubber Goods of Ultimate Economy

Send for free Sample

JERSEY CITY, N. J.

Birch
Pump Valves



consist of a one-piece bronze metal body with two rubber inserts securely locked into body. Adaptable for hot or cold water service. Will not warp, break nor ride bridges of the seat. Efficient, simple and dependable. Hold world's record. Ask for bulletin.

BIRCH MFG. CO., 1521-23 Sedgwick Street, Chicago, Ill.

Guaranteed Service

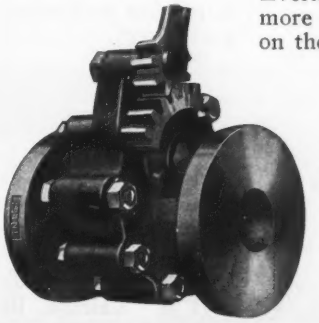
is what you want down back of your boilers where the blow-off is installed

Everlasting Blow-Off Valves

are guaranteed on blow-off service up to 250 lbs. pressure and for **two years.**

If they fail in any way we will replace without charge or refund the money—just as you wish.

Write for a copy of the Scully booklet which shows the distinctive features which enable Everlasting Valves to more than make good on the guarantee.



Scully Steel & Iron Co.
P. O. Box 814
Chicago, Ill.

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1000% OIL FILTER

Sounds incredible, doesn't it?

This is the Filter that "Laid the Golden Egg."

The filter referred to in the letter at right cost this company $128.00. They will save $1172.00 in oil alone the first year, nearly ten times the cost of the filter, or about the cost of the filter every month.

Send for a catalogue of this wonderful oil filter. It automatically rings a bell and tells the engineer when it needs cleaning also. What do you think of that?

WM. W. NUGENT & CO.

Manufacturers of
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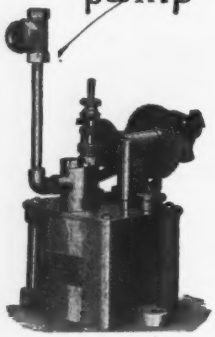
"We are entirely satisfied with the work you did for us."
(We will gladly send you the name and address of this company upon request)

Dependable.

Service records on Hills-McCanna Lubricators show double the length of life of the ordinary pump



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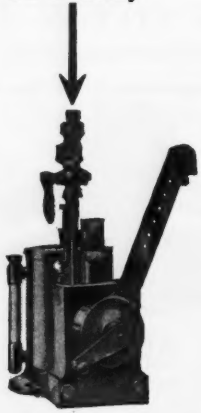
Hill-McCanna Co. 2025 Elston Ave. Chicago, Ill.

ROCHESTER
Automatic Lubricators

The Sight Feed Shows the Actual Oil Delivery



They are life preservers of engines and boosters of power output. Automatically furnish an unfailing supply of oil, regulated as required, which reduces friction and saves 25 to 60 per cent of lubrication costs. Noiseless and positive.

All types furnished for all conditions. Clutch, Ratchet and Rotary Drives.

Write for Catalog T.

Greene, Tweed & Co.
109 Duane St., New York

Factory at Newark, N. J.
Canadian Agents: Darling Bros., Ltd., 120 Prince St., Montreal.
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Ask for 30 Days' Free Trial

Here's a Bargain in Oil

Free Trial—Not One Cent of Risk

Also Manufacturers of Service Water Heaters and Open and Closed Feed Water Heaters.

A STRAIGHT reduction of 65 per cent in oil bills is offered to any power plant that is now throwing away used, dirty oil. This offer has no strings attached to it. We will even send the Sims Oil Filter without one cent of cost to you for a 30-day free trial that you may prove in your own plant and to your own satisfaction that the Sims Filter saves the oil. Furthermore, there is no appreciable expense for operation or upkeep to offset the savings effected. Just write today for full information and sizes so that you may tell us the size filter you want sent. That's all there is to it. Do it now. Address

The Sims Company
2001 Holland St.
Erie, Pa., *A good place in which to live, to work and to play*

"FELTHAUSEN"
HAND CYLINDER
OIL PUMPS
Brass or Glass Body
Nos. 3, 04, 4, 5 & 8 side outlet

Valuable for Oiling Inaccessible Journals

By using a 2-outlet cock, two journals can be oiled at once. These pumps absolutely prevent engine bearings from scoring when starting up after layby.

Write for catalog No. 18-4

Sherwood Manufacturing Company
Brass Founders and Finishers
Sole Manufacturers of Sherwood Engineering Specialties
1711 ELMWOOD AVENUE, BUFFALO, N. Y.

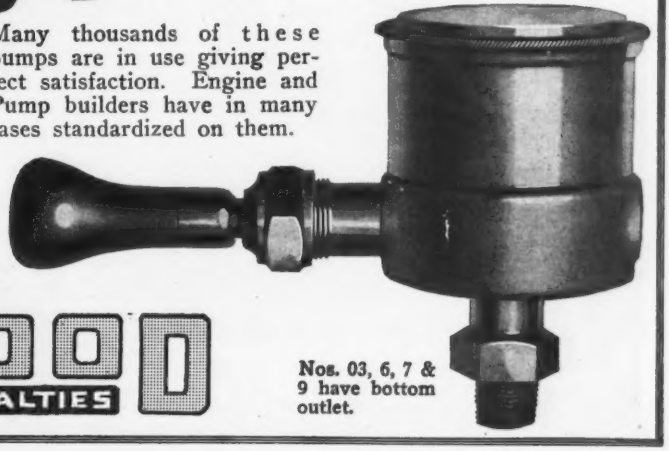
SHERWOOD
ENGINEERING-SPECIALTIES

Protects the cylinders of your pumps and engines

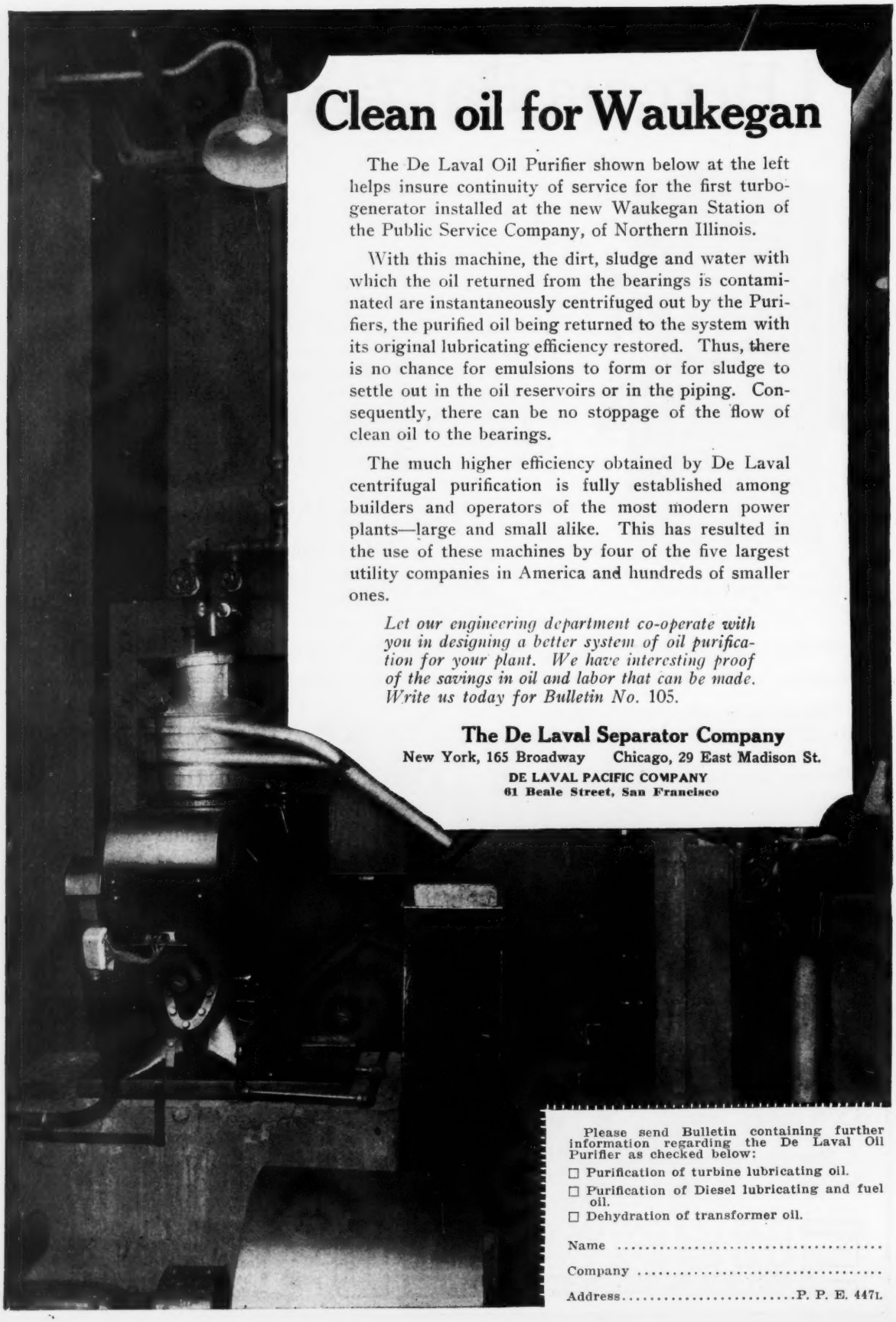
Anyone can readily understand how to operate these accurately made and elegantly finished pumps.

Two ball check valves take place of external M. and F. valves
and keep steam from fogging glass of glass body type.

Many thousands of these pumps are in use giving perfect satisfaction. Engine and Pump builders have in many cases standardized on them.



Nos. 03, 6, 7 & 9 have bottom outlet.



Clean oil for Waukegan

The De Laval Oil Purifier shown below at the left helps insure continuity of service for the first turbo-generator installed at the new Waukegan Station of the Public Service Company, of Northern Illinois.

With this machine, the dirt, sludge and water with which the oil returned from the bearings is contaminated are instantaneously centrifuged out by the Purifiers, the purified oil being returned to the system with its original lubricating efficiency restored. Thus, there is no chance for emulsions to form or for sludge to settle out in the oil reservoirs or in the piping. Consequently, there can be no stoppage of the flow of clean oil to the bearings.

The much higher efficiency obtained by De Laval centrifugal purification is fully established among builders and operators of the most modern power plants—large and small alike. This has resulted in the use of these machines by four of the five largest utility companies in America and hundreds of smaller ones.

Let our engineering department co-operate with you in designing a better system of oil purification for your plant. We have interesting proof of the savings in oil and labor that can be made. Write us today for Bulletin No. 105.

The De Laval Separator Company

New York, 165 Broadway Chicago, 29 East Madison St.

DE LAVAL PACIFIC COMPANY

61 Beale Street, San Francisco

Please send Bulletin containing further information regarding the De Laval Oil Purifier as checked below:

☐ Purification of turbine lubricating oil.

☐ Purification of Diesel lubricating and fuel oil.

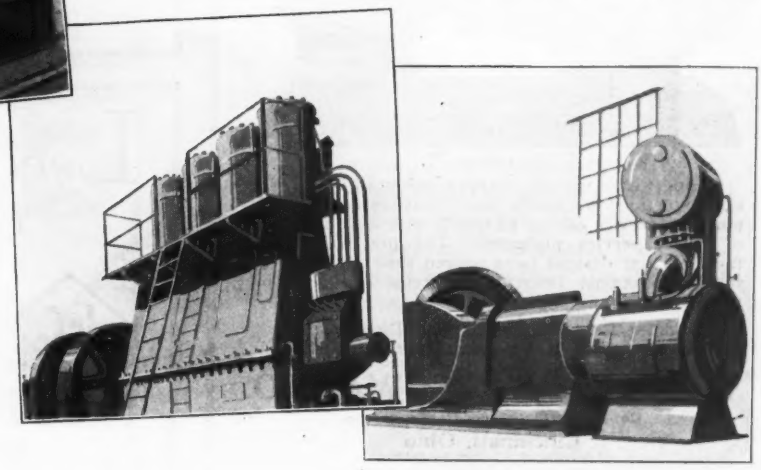
☐ Dehydration of transformer oil.

Name .....

Company .....

Address.....P. P. E. 447L

IN POWER PLANTS



The turbine, the Diesel and the steam engine have found a reliable guardian for the long life of their bearings—the Sharples Super Centrifuge.

Three fundamental demands of the power plant are:

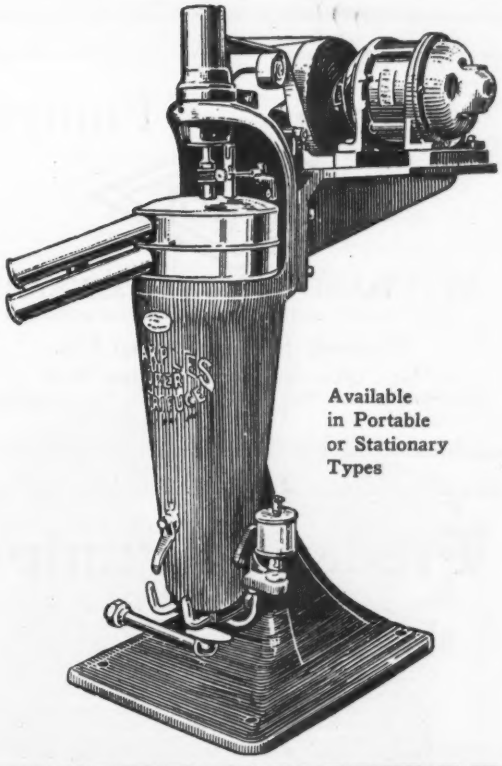
1. High efficiency and maximum power development.
2. Dependable performance under continuous operation.
3. High quality and purity of lubricants for the power units.

In the fulfillment of these requirements the Sharples Super Centrifuge is a vital factor. It protects bearings of power units by insuring a constant supply of purified lubricating oil.

Super Centrifugal Force—13,000 times as great as gravity — eliminates moisture and suspended impurities.

The Sharples Super Centrifuge is easy to operate, easy to clean and easy to care for.

Progressive power plant engineers prefer the Sharples Super Centrifuge as the ideal and most economical means of keeping their turbine, steam engine or Diesel operating at maximum efficiency—because the bearings are continuously safe-guarded by Super Centrifuged oils.



Available in Portable or Stationary Types

THE SHARPLES SPECIALTY COMPANY
2300-2322 Westmoreland Street, Philadelphia
Representatives in all principal industrial territories

SHARPLES SUPER CENTRIFUGAL FORCE

McGOWAN PUMPS

"The Standardized Line"

Centrifugal and Rotary Pumps—Deep Well Power Heads—Single and Duplex Steam and Power Driven Pumps—Simple, Compound and Triple Expansion Pumping Engines with related equipment.

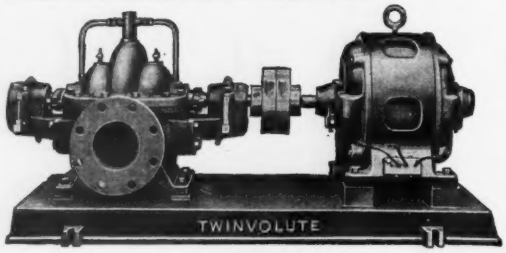


FIG. 552

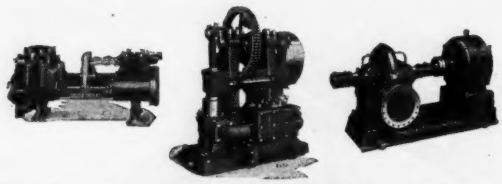
Owing to the variety of types embraced in our line of production, practically every feasible condition of pumping service can be efficiently met with any form of power service preferred. The practical refinements in our designs have proven their worth as an insurance against interrupted service and resultant plant losses.

Address Dept. G, Engineering Division, for recommendations, estimates or proposals.

THE JOHN H. McGOWAN CO.

General Offices: 64 Central Ave.

Cincinnati, Ohio



Platt Iron Works

Dayton, Ohio

"Platt" and "Smith-Vaile" Pumps

Steam and Power Pumping Machinery

Lecourtenay *Centrifugal* Pumps

L-C

Write for bulletins and consult our experienced engineers

LECOURTENAY COMPANY

Maine Street, Newark, N. J.

Warren Pumps

WARREN

STANDARD FOR OVER 25 YEARS

Select them for severest service and highest economy.

Warren Steam Pump Co.

Main Office and Works: Warren, Mass.

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Bethlehem-Weir Turbo-Feed Pump

A Single Stage, Moderate Speed High Duty Boiler Feed Pump.

Compact—self-contained—scientifically designed—hydraulically controlled—of low steam consumption—occupies minimum space.

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General Sales Offices: 25 Broadway, New York City.

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Frederick Pumps

For boiler feed service no pumps effect more enduring economies than Frederick Pumps. The design, simple and practical; the rugged construction, and their past performance are the facts on which we base claims.

Write for literature on these and other Frederick Products which include: Centrifugal Pumps (Single and Multi Stage), Boiler Feed Pumps, Sewage Pumps, Sugar Mill Pumps, Pulp Pumps, Vacuum Pumps, Ash Conveyors, Ash Bins and Ash Gates.

The Frederick Iron & Steel Co.

Frederick, Maryland

TABER PUMPS

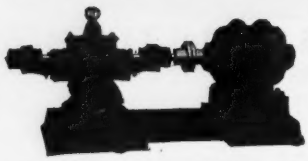


Fig. 510 illustrates Taber Double Suction Centrifugal Pump.

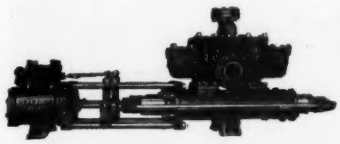
Over 40 years of specialized pump building experience stand behind every Taber Pump.

Is our "Silent Sales Engineer" calling on you regularly?

If not, write for "him."

TABER PUMP CO. 298 Elm Street, BUFFALO, N. Y.

Builders of Centrifugal and Rotary Pumps



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For All
Purposes

We have a sales correspondent in your vicinity.
We have built good pumps for 50 years.
New York Sales Office: 149 Broadway

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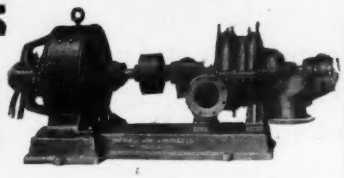
EARLE
CENTRIFUGAL
PUMPS



Efficiency Quality HIGH
Repairs Operation LOW

The Earle Gear & Machine Co., 4715 Stenton Avenue Philadelphia, U. S. A.

MANISTEE
"ROTURBO"
CENTRIFUGAL PUMPS
ROTARY JET CONDENSERS
Manistee Iron Works Co., Manistee, Mich.

Yeomans
Automatic Electric
Bilge Pumps
Single and duplex units. Write for Bulletin No. B-3200.
Agents in Principal Cities
Yeomans Bros. Co., 1432 Dayton St. Chicago, Ill.
Established 1898
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Dependable Equipment

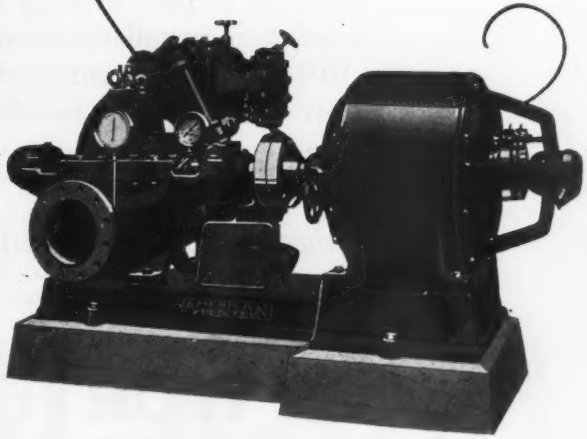
AMERICAN
AURORA, ILL.

Fire Pumps!

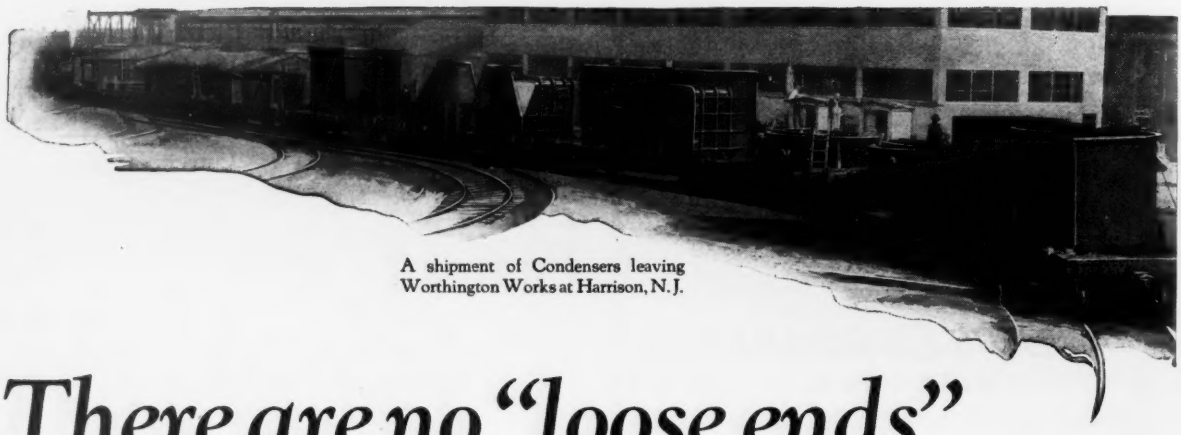
Sturdy, dependable "American" Fire Pumps respond immediately to the demands of the emergency! The improved types of "American" single stage and two stage Fire Pumps are the result of years of design and manufacture, and are fully approved by the National Board of Fire Underwriters.

Made to exact standards and to meet definite requirements as to efficiency and pressure. Repairing parts are easily obtained.

Every pump is absolutely guaranteed for specific performance and duty under the conditions for which it is recommended. Look for the trademark—it is your guarantee!



GENERAL OFFICES and WORKS - AURORA, ILL. CHICAGO OFFICE - FIRST NATIONAL BANK BLDG.
THE AMERICAN WELL WORKS



A shipment of Condensers leaving Worthington Works at Harrison, N. J.

There are no "loose ends" on a Worthington job

IT IS a habit with power companies which possess one or more Worthington condenser and pump installations, when they need additional equipment, to come back to Worthington for it.

It isn't hard to see the reason.

These companies [some of the largest and most successful in the country, too] have found that to install a Worthington condenser, with Worthington also supplying the auxiliaries, means to dispense with all worries as far as that part of the job is concerned. The same Worthington guarantee, the same Worthington workmanship and care in all details, covers it all.

The Union Gas & Electric Company of Cincinnati, for example, in 1916 ordered two complete Worthington condenser installations for the West End station. In 1919 they added another. And now, in the new Miami Fort station, whose condensers have the call?

Worthington, of course.

WORTHINGTON PUMP AND MACHINERY CORPORATION
115 BROADWAY, NEW YORK, U. S. A.
BRANCH OFFICES IN 24 LARGE CITIES

WORTHINGTON

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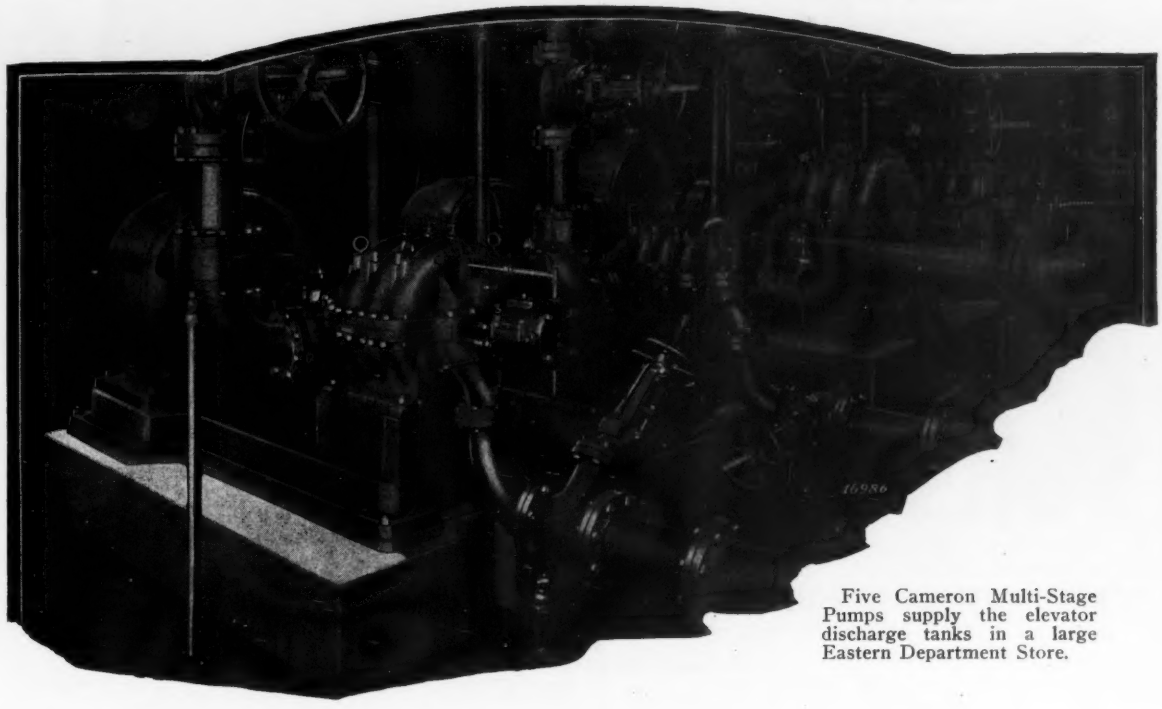
Cameron Pumps on Elevator Service



Five Cameron Multi-Stage Pumps supply the elevator discharge tanks in a large Eastern Department Store.

THESE five Cameron Multi-Stage Pumps supply the discharge tanks on a plunger elevator system of one of the best department stores in the East. Approximately sixty thousand customers daily—many of them women—demand comfortable service.

Cameron Pumps were chosen because of their dependability. These pumps were designed for this particular service. Every detail of construction was developed in accordance with modern engineering theory and practise.

Their reliability and economy is the result of sixty years' experience in building the better kind of pumps.

The counsel and co-operation of Cameron Engineers are always at your disposal without expense or obligation. Consultation with Cameron Engineers results in an installation which will give absolute satisfaction.

Complete set of bulletins on request.

195DV

INGERSOLL-RAND COMPANY, 11 BROADWAY, NEW YORK CITY.

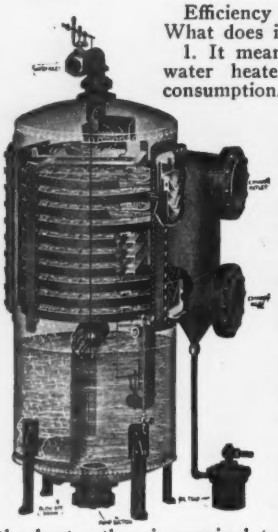
Offices in principal cities the world over.

For Canada Refer—Canadian Ingersoll-Rand Co. Limited, 260 St. James Street, Montreal, Quebec

Ingersoll-Rand

A. S. CAMERON STEAM PUMP WORKS

The Stickle Feed Water Heater and Purifier



Efficiency in a Feed Water Heater! What does it mean?

1. It means the greatest amount of water heated with the least steam consumption.

2. It means the greatest amount of scale forming matter deposited in the heater.

3. It means the complete elimination of cylinder oil from the feed water.

1. **Efficiency in Heating:** Means the greatest amount of water surface exposed to steam.

2. **Efficiency in Purification:** Means the greatest amount of tray surface on which scale forming matter will deposit.

3. **Efficiency in Oil Separation:** Means the induction type heater with an efficient oil separator. No more steam enters the heater than is required to heat the water. Perfect oil separation guaranteed.

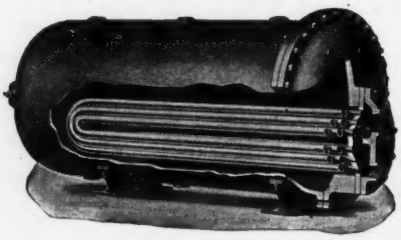
STICKLE STEAM SPECIALTIES CO.

Factory at Indianapolis, Ind.

Branches

Boston, Mass. **Philadelphia, Pa.**

Manufacturers of Steam Traps, Vacuum Heating Traps and Specialties, Oil and Steam Separators, Pressure Controlling Devices and Unit and Hot Blast Heaters.



Easy to get at

The National heating element can be taken out in a jiffy for cleaning or repair. Another reason why "out-of-service" periods are practically unknown to National users.

Write for Bulletin No. 65

THE NATIONAL PIPE BENDING CO.

160 River Street
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Canadian Sales Representative: Grant E. Cole Co., Toronto, Ont.

7470

Hotter Feed Water
with Reilly Heaters
Will Save Fuel and Add to Your Boiler Capacity

If you are not now heating your feed water to within a very few degrees of the boiling point, your operating costs are higher than they should be with present boiler equipment.

Very hot feed water is a recognized essential in all the leading power plants today. An efficient feed water heater is an important element in the proper functioning of your plant. It can earn money for you by saving fuel, preventing needless shock and internal stresses in boilers and increasing the ultimate steaming capacity.

Send for our booklet which will tell you the features that you should most carefully consider in selecting your feed water heater. It goes fully into the advantages offered by the

REILLY WATER HEATER

THE GRISCOM-RUSSELL COMPANY

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Philadelphia	**Chicago**	**St. Louis**	**New Orleans**	**San Francisco**
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For Canada: Riley Engineering Co., Ltd., Toronto

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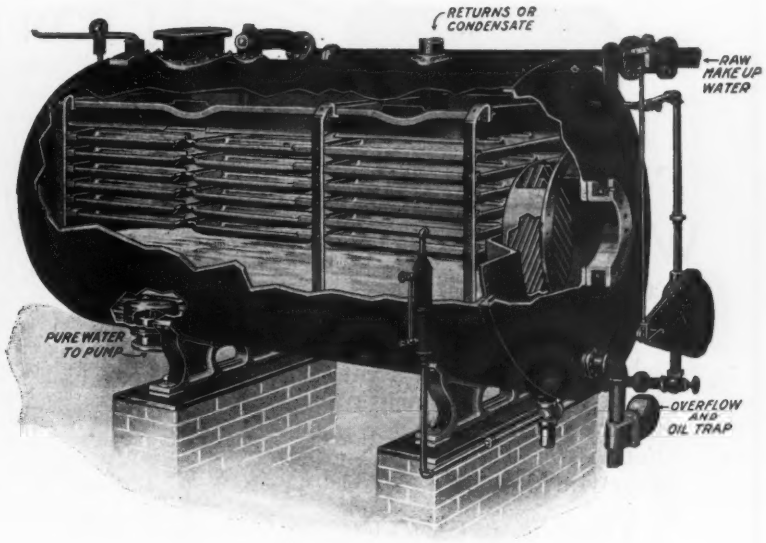
Company .....
Address .....
The Griscom-Russell Co.,
2141 West Street Building,
New York.
Please send a copy of your
Bulletin No. 260.
12-15-24

Hoppes Feed Water Heaters

save money at the source of production



Hoppes Double Service Heater

Cut plant operation costs to a minimum, then production costs will automatically lower themselves, and the product can be delivered to the consumer at a lower cost but with the same or better margin of profit for the producer.

Hoppes Feed Water Heaters save fuel and remove scale-forming substances before the water gets into the boiler. Cost almost nothing to operate and maintain.

Where the Hoppes is used the boiler tubes remain clean. Shut-downs for cleaning and repairs are few and far between and maximum loads with minimum fuel consumption are assured.

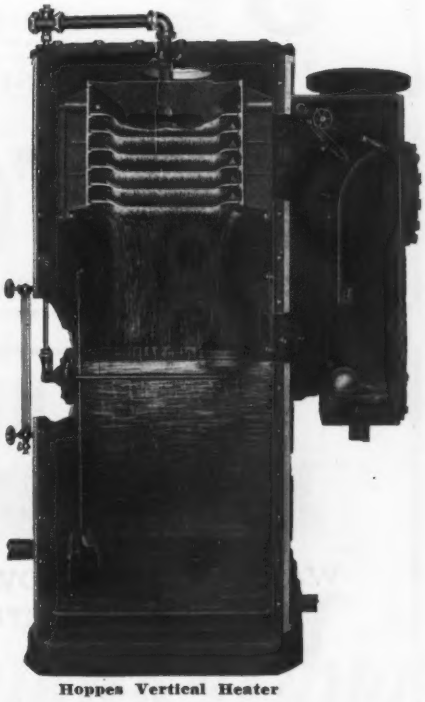
Figure these advantages out for yourself and compare them with your present conditions.

Is there room in your plant for improvement that will effect great savings? No doubt more than can be estimated if you cannot boast of a Hoppes Feed Water Heater installed in your plant.

It has a large heating and lime-catching surface. The water flows constantly in thin films in direct contact with the steam, a feature which insures the highest possible temperature and complete purification to the feed water. Each Hoppes is equipped with an efficient oil separator and an accurate, automatic feed-water control. Parts are easily accessible for cleaning.

Steel or cast iron construction with or without extra water storage capacity.

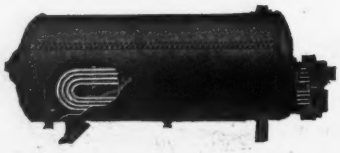
We also manufacture V-Notch Water Meters, Live Steam Purifiers, Exhaust Heads and Steam and Oil Separators.



Hoppes Vertical Heater

The Hoppes Mfg. Co.

70 Larch Street Springfield, Ohio



The Patterson Hot Water Service and Storage Heater

when supplied with either exhaust or live steam, will furnish all the hot water you want, as hot as you want it, and whenever you want it.

There is a PATTERSON HEATER, in both storage and heating capacity, just suited to your requirements.

Patterson-Kelley Co.
Architect's Building
New York City

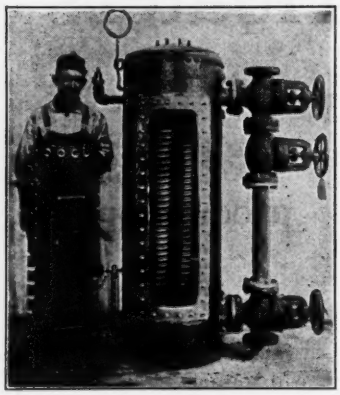
DON'T CHILL BOILERS

Eliminate unequal expansion and contraction strains that result in cracked plates, leaky seams and save fuel and increase boiler efficiency by heating feed water with exhaust steam with the

"SW" MULTICOIL
Feed-Water Heater

It is the all-around practical heater which has low upkeep, leakproof connections, interchangeable coils, and maximum efficiency of heating surface.

Bulletin No. 103 contains interesting details. Write for it.



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of New Jersey
Hampton, New Jersey
New York, Chicago, Boston, Philadelphia

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ELESCO

DESIGNING ENGINEERS AND MANUFACTURERS OF ELESCO STEAM SUPERHEATERS FOR LOCOMOTIVE MARINE AND STATIONARY BOILERS, FEED WATER HEATERS, PIPE COILS, ETC.

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FOR CANADA: THE SUPERHEATER COMPANY, LIMITED, MONTREAL

17 East 42nd Street NEW YORK

THE SUPERHEATER COMPANY

Peoples Gas Building CHICAGO

ECONOMIZERS

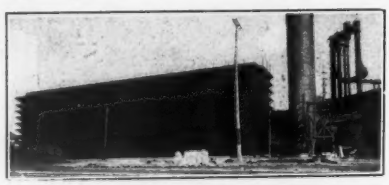
reduce fuel costs by making use of waste exhaust gases to preheat the boiler feed. Patented construction proven by 20 years of service.

FOSTER

SUPERHEATERS

Improve engine, turbine and boiler economy by enabling a given amount of steam to do more work. Over 10,000 installations in stationary power plants.

POWER SPECIALTY COMPANY, Boston, Philadelphia, Pittsburgh, Kansas City, Chicago, San Francisco, Dallas, Detroit, Boulder, London, Eng. **111 Broadway, NEW YORK**



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SPRAY NOZZLE SYSTEMS
AIR WASHERS

Write for Folder F

THE COOLING TOWER CO., Inc., 13 John St., New York

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"Better than Specified"

CONDENSERS
Surface — Low Level Jet—Barometric - Distilling.

COOLERS
For oil, water and all liquids.

EXPANSION JOINTS
Crosshead-Guided and Internally-Guided.

DE-AERATORS

EVAPORATORS

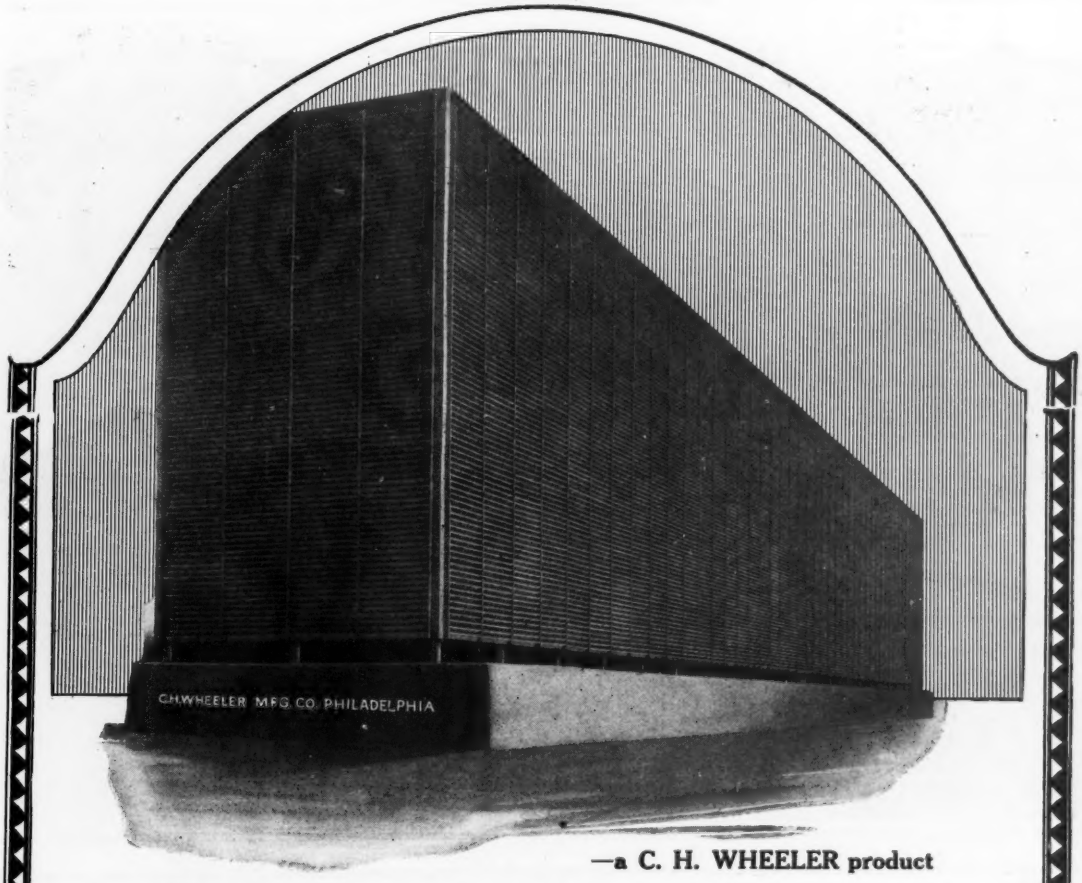
HEAT EXCHANGERS

HEATERS
Bleeder—high and low pressure, Boiler Feed —Chemical— Hot Water System—Oil—Storage—Sugar Juice.

STRAINERS
Duplex, continuous service type.

ROSS HEATER & MFG. CO., Inc.
BUFFALO, N. Y.

Agents in all principal cities



—a C. H. WHEELER product

Tide water vacuum with recooled water at Charleston, West Virginia

It can be obtained at any inland point with a limited supply of condenser cooling water by the installation of a C. H. Wheeler Cooling Tower, which secures the maximum temperature reduction in re-cooling the water under the existing atmospheric conditions.

C. H. Wheeler Cooling Towers are furnished in three general types—forced draft; natural draft-open louvre; and combined natural and forced draft.

More efficient than a cooling pond and occupy much less ground space. No danger from clogging. The water is continuously broken up and remains in direct contact with the air for a much longer period. Hence the cooling effect is greater and a higher efficiency is achieved.

Every C. H. Wheeler Cooling Tower is designed by experts after a study of all the conditions that affect its operation.

We will be pleased to study your operating conditions and to submit our recommendations for the most efficient type and size condenser for your plant.

C. H. WHEELER MFG. CO.

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Philadelphia, Pa.

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Surface Condensers
Jet Condensers
Vacuum Pumps
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Direct Acting Steam Pumps
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Engines
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Cooling Towers
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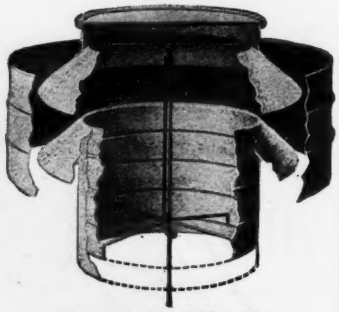
Burt Metal Top Cone Damper Ventilator.

Pure Air for 1925

Proper ventilation that removes smoke, gas, dust and excessive heat makes men more alert and efficient and adds to savings in equipment and operation. Start the new year with the assurance of increased profits by selecting from the big Burt Ventilator Catalog the correct ventilator—durable, automatic and ornamental—that will meet your particular problems. We have a type for every purpose.


Burt Glass Top Sliding Sleeve Damper Ventilator.

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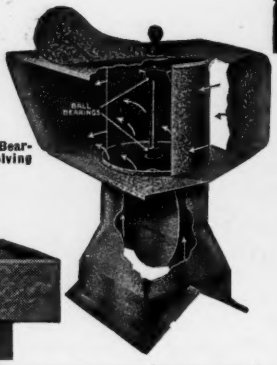
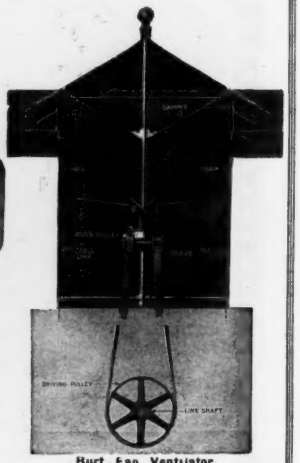
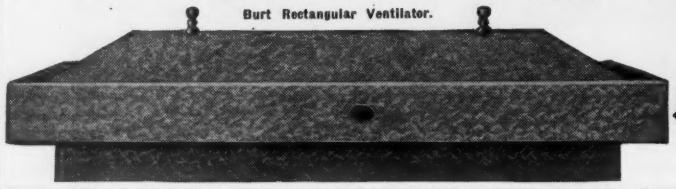
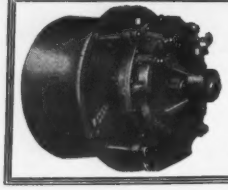
Pioneer Oil Filter Manufacturers
The Canadian Fairbanks-Morse Co., Ltd., Montreal, Sole Representatives for Burt Oil Filters and Burt Exhaust Heads for Canada.
George W. Reed & Co., Ltd., Montreal, Sole Manufacturers of Burt Ventilators for Canada.


Burt Ball Bearing Revolving Ventilator.


Burt Fan Ventilator.


Burt Rectangular Ventilator.



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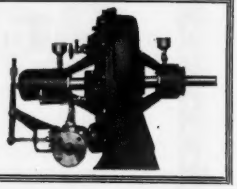

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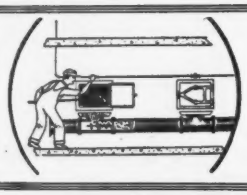

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The Conveyor With Exterior Wear Sections
STORAGE BINS FOR ASH AND COAL
Let our Consulting Department advise you on your Ash Disposal Problem. Write for Catalog showing Actual Installations.
UNITED CONVEYOR CORPORATION, 1530 OLD COLONY BLDG., CHICAGO, ILLINOIS

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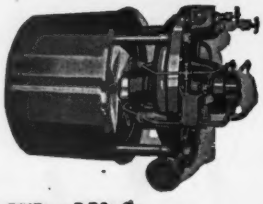

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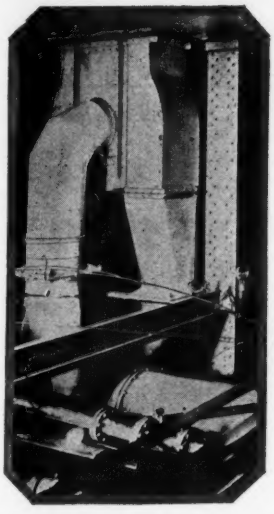
Sturtevant Fans Were Selected at Cahokia

One of the Sturtevant Cindervane Fans at Cahokia.



A Sturtevant Steel Plate Fan at Cahokia.

At the great Cahokia station of the Union Electric Light and Power Company of St. Louis, Mo., two 8-foot Sturtevant Cindervane Fans are installed. These fans handle 60,000 cubic feet of air per minute with 6-inch resistance at the inlet side at an air temperature of 150°. Each fan operates at a speed of 435 R.P.M. and are used in connection with the drying of pulverized fuel.

This is but one instance of many installations of Sturtevant equipment selected by the country's foremost engineers for efficient operation. Our engineering staff will gladly co-operate with you in the selection of suitable air-moving equipment.

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997

Weller Skip Hoist

handling Ashes at

Montgomery Ward & Co's Chicago Plant

We design and make a complete line of

Coal and Ash Handling Equipment

including

Apron Feeders	Spiral Conveyors	Skip Hoists
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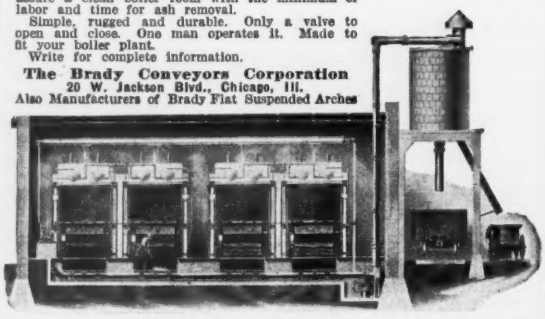

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Another "STEARNS" Conveyor

You can unload, and deliver to boats, one car of coal in three minutes with "Stearns" Conveyors.

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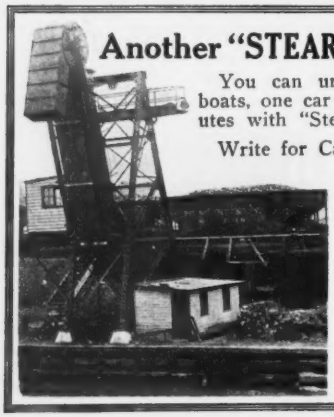

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Sixteen Years of Honest, Earnest Effort

to produce the best equipment of its kind have resulted in the

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the last word, in our opinion and in that of our customers, in economical ash removal. May we send you a copy of the new catalog that shows on what our faith and theirs is founded.

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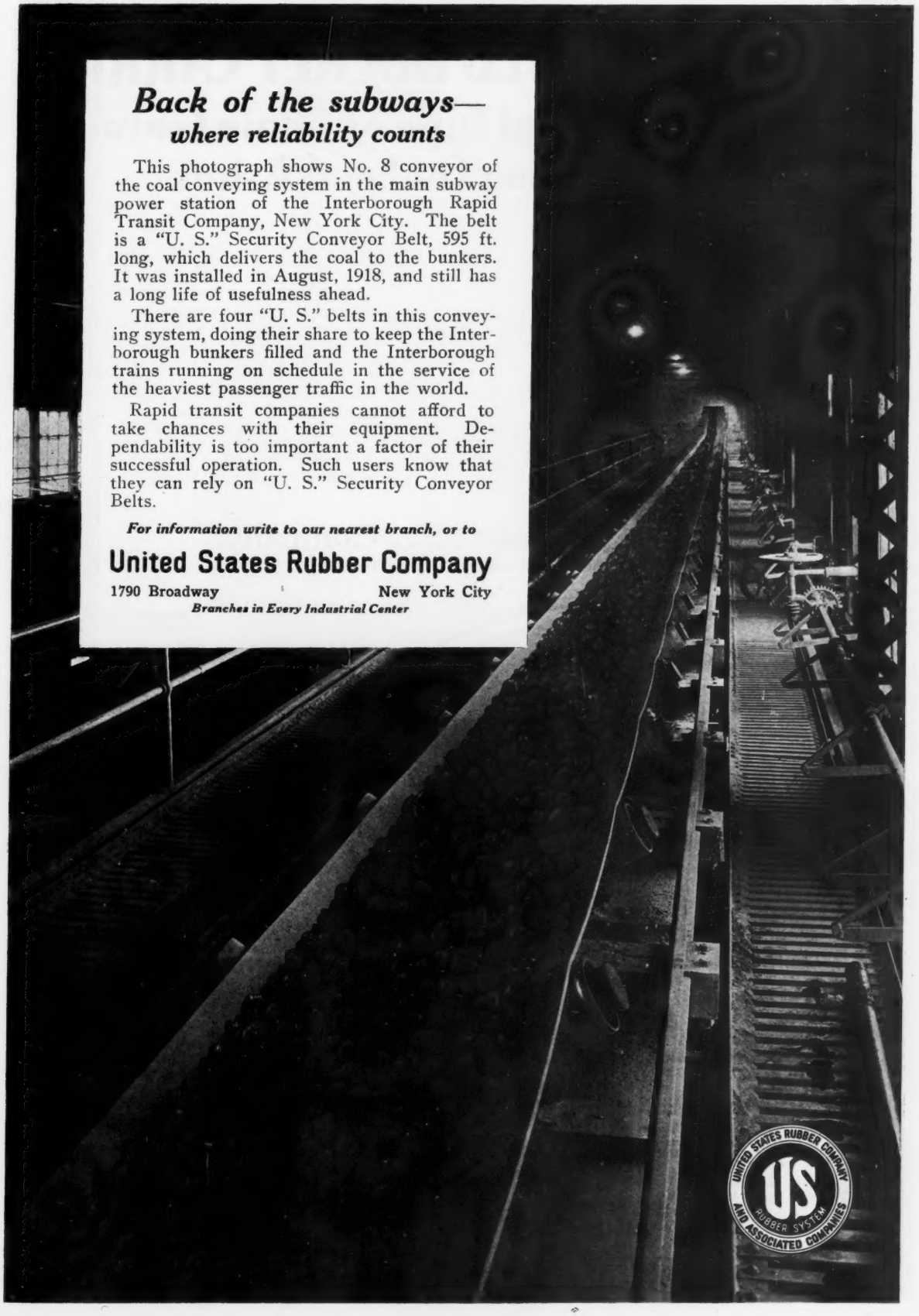

Back of the subways—
where reliability counts

This photograph shows No. 8 conveyor of the coal conveying system in the main subway power station of the Interborough Rapid Transit Company, New York City. The belt is a "U. S." Security Conveyor Belt, 595 ft. long, which delivers the coal to the bunkers. It was installed in August, 1918, and still has a long life of usefulness ahead.

There are four "U. S." belts in this conveying system, doing their share to keep the Interborough bunkers filled and the Interborough trains running on schedule in the service of the heaviest passenger traffic in the world.

Rapid transit companies cannot afford to take chances with their equipment. Dependability is too important a factor of their successful operation. Such users know that they can rely on "U. S." Security Conveyor Belts.

For information write to our nearest branch, or to

United States Rubber Company

1790 Broadway **New York City**

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UNITED STATES RUBBER COMPANY US RUBBER SYSTEM AND ASSOCIATED COMPANIES

PERKINS PIVOTED BUCKET CARRIER

The Most Practical Type *of* Chain Conveyor *for* Handling Coal and Ashes

Power house requirements are just as vital as the requirements in any other department of your plant. The distribution of coal into bunkers and removal of ashes requires efficient machinery such as will reduce costs.

Modernization does not imply rebuilding your plant. Efficient coal and ashes handling equipment can be installed without jeopardizing production. Many power plants have been modernized the Webster way and have paid for themselves out of the savings effected.

Does your plant need modernizing? Is your coal handled efficiently? Does the removal of ashes give you concern? If so, a Perkins Pivoted Bucket Carrier or any of the power plant equipment listed below will cut down costs and make your plant efficient.

A Webster Engineer will be glad to confer with you and advise suitable equipment to reduce costs. Almost a half century stands behind Webster products and this background of experience is your guarantee.

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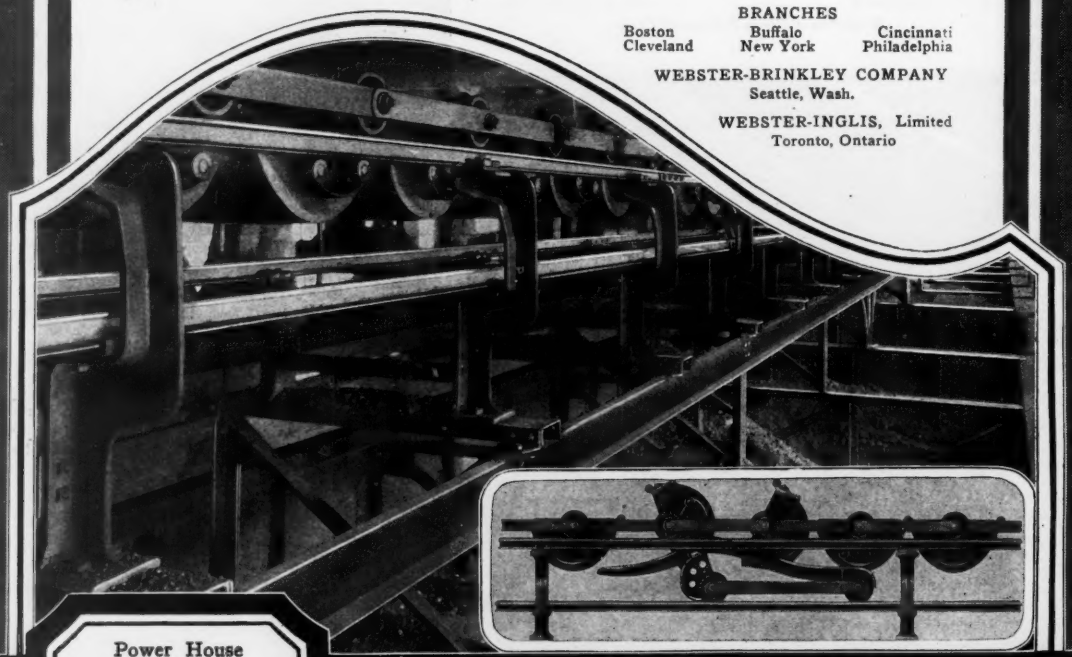
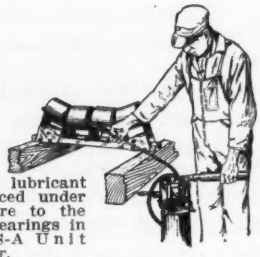


Power House Equipment

Track Hoppers and Feeders
Pivoted Bucket Carriers
Weigh Larries
Apron Conveyors
Ash Skip Hoists
Belt Conveyors
Bucket Elevators
Flight Conveyors
Coal Bunkers and Gates and
Stoker Spouts

WEBSTER

S-A BELT CONVEYORS



The lubricant is forced under pressure to the ball bearings in the S-A Unit Carrier.

ACQUIRING the devices and equipments which are the result of correct engineering design and careful workmanship is to insure your probability of continuous operation, free from troublesome shutdowns. With a record indelibly stamped with hundreds of successful installations in service for years, the S-A Unit Carrier equipped belt conveyor towers as the outstanding equipment of its kind.

They make a Friend of Every Operator

ASK FOR THE FOLDER "THE NEW S-A UNIT CARRIER"

Stephens Adamson MFG CO AURORA ILLINOIS

How to Cut Ash Removal Costs in Half

1500 power plants in the United States and Canada have cut their ash removal costs to a marked extent because they installed in their boiler rooms AMERICAN STEAM JET ASH CONVEYORS.

Many of them were able to make savings amounting to 50-75% of the costs of previous methods. All of them are enthusiastic about the economy and labor-saving abilities of the equipment.

Labor Saving

The installation of an AMERICAN STEAM JET ASH CONVEYOR cuts the ash handling crew to one man. No longer will the gang shovel, hoist, reshovel and wheel ashes from pits to outside pile. With the American system, ash disposal consists of one operation—the simple matter of feeding the ashes into an intake opening placed handily right before the ash pits.

Minutes for Ash Removal

Ashes are handled at high speed—hours of ash handling are reduced to minutes. "Two or three minutes at each cleaning is all the time needed now," asserts one user. "Our ashes are handled at a rate averaging 8 tons per hour."

The capacity of the conveyor, of course, depends upon plant conditions, systems with a short discharge line operating at a slightly higher speed.

Dustless Ash Removal

Handling ashes with the AMERICAN STEAM JET ASH CONVEYOR is a dustless operation. The suction of the jet of high velocity steam through the conveyor line draws with it the dust which normally would rise in the boiler room. Thus bearings of engines and other sensitive parts of the equipment are kept free from flying particles of ash.

When the ashes are discharged into a storage tank equipped with our dust eliminator, the steam emerging from the vent is free from all traces of dust. It comes out snow white.

Dustless ash handling is a boon to many plants located in residential districts, in congested business sections, or at factories where cleanliness is essential.

The dustless operation of the conveyor is covered by guarantees.

No Freezing Ashes

Ashes discharged into the ash receptacle falls loosely and does not pack. It is free from dampness. In winter it does not freeze.

Engineering Services

We have an experienced engineering staff which is ready at all times to co-operate with your engineers in designing ash handling equipment to exactly meet your local conditions. Send us blueprints or sketches of your boiler-room, together with information relating to number and make of boilers, type of stokers, preferred location of disposal point, etc.

Without obligation on your part, we will lay out for you a system which will meet your needs.

Sign the coupon below for literature or a district engineer to explain our proposition in detail.

Fill Out Clip and Mail →

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Perhaps conditions are such that you, too, can cut costs—send the coupon at right for valuable information.

Conveyors Corporation of America,
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Please send promptly information about the American Steam Jet Ash Conveyor.

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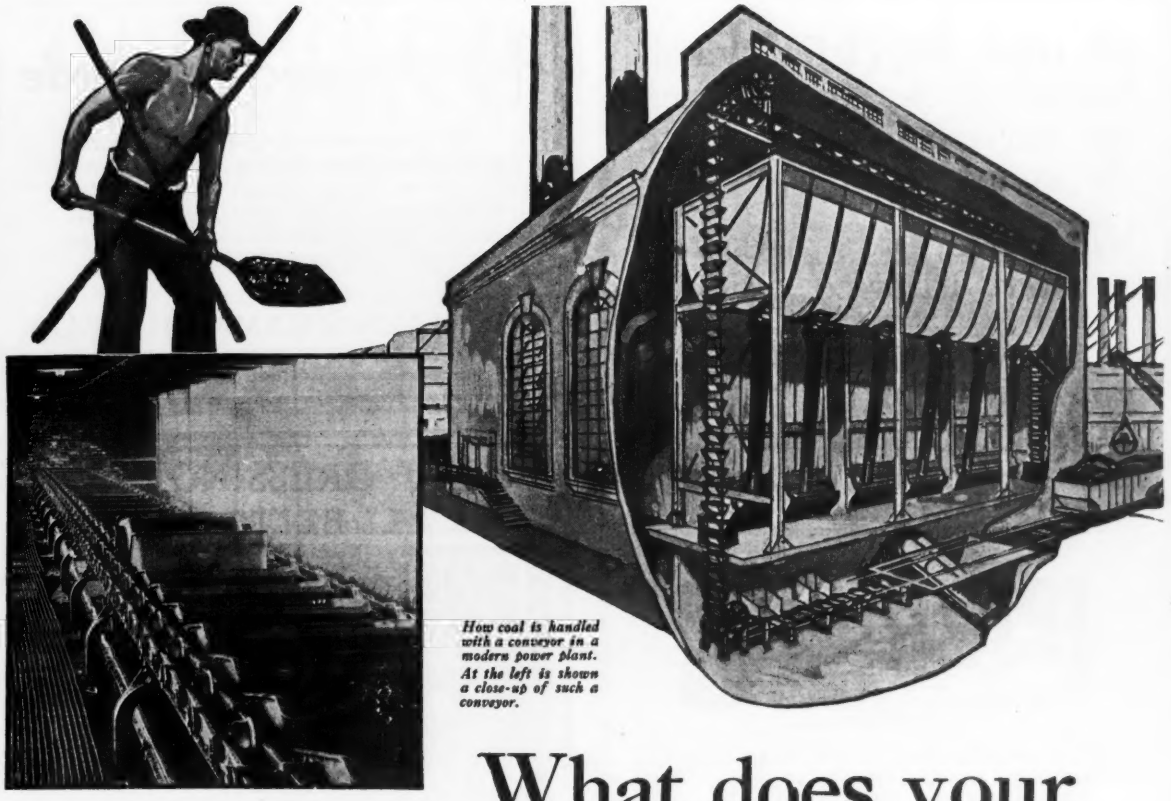

How coal is handled with a conveyor in a modern power plant. At the left is shown a close-up of such a conveyor.

What does your fuel cost—f. o. b. boilers?

Not just the cost per ton in the car. Add to that your handling cost—the expense of getting the coal to your boilers, where it does its work. Every dollar saved in handling cost means just that much saved in the cost of your power.

Many owners of modern power plants have realized substantial savings in handling coal by Brownhoist conveyor methods. Such conveyors set down your fuel where you use it at the lowest possible cost per ton.

Brownhoist has been a pioneer and a leader in designing and building economical handling machinery. Put the wide experience of the Brownhoist Engineers to work for you in devising new economies for your power plant. Their advice is yours for the asking.

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If there's a warehouse in your city, you'll find it in the phone book. If there's none in the book, write for nearest address.

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Rust hasn't a chance on equipment and buildings painted with BITUMASTIC SOLUTION. This specially made paint combines all the qualities required in and around a power plant. It withstands successfully and for long periods, high temperatures, condensation and fumes. It prevents rust, sheds dust and keeps plant and equipment clean and bright.

BITUMASTIC SOLUTION is the standard paint in many of the most modern power plants in America.

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4—Withstands 3100 deg. Fahr.
5—Fine ground, making more dense and harder wall.

More Facts

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Ramit makes practically indestructible, solid, monolithic, jointless linings for every type of high temperature furnace. **It stands wear and tear,** does not shrink in setting, does not crumble or craze, and can be fired while damp. Stands the highest temperatures with greater durability than the best fire brick. Saves repairs and replacements.

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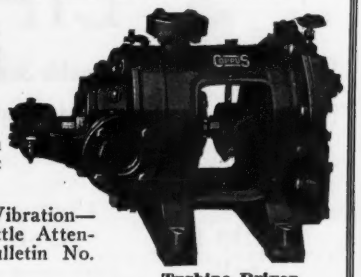
A Single Unit. Steam Turbine or Electric Motor Driven.

Steady Flow—No Vibration—High Efficiency—Little Attention. Write for Bulletin No. 125.



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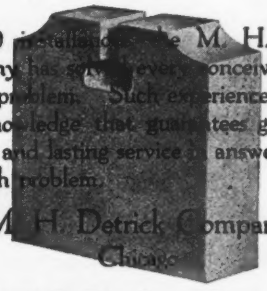
In 7000 installations the M. H. Detrick Company has solved every conceivable type of arch problem. Such experience has built up a knowledge that guarantees greater efficiency and lasting service as an answer to your own arch problem.



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Transmit power from ¼ to 5,000 H.P. with positive speed ratio, 98.6% constant efficiency, quiet operation at all speeds, any convenient distance between sprocket centers, occasional lubrication, long life, low up-keep cost. Unaffected by heat, cold or moisture.

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Half a century of specialized experience and outstanding service, particularly in refractories for crucibles and industrial furnaces, where highest temperatures and most difficult conditions prevail, is at your service.

Rapid advance along similar lines in power plant practice caused leading engineers to turn to this house for the better furnace linings required to meet the extreme conditions of the boiler furnace of today.

Ramtite is meeting these requirements throughout the power plant field. It's a plastic material that makes a complete monolithic lining, makes the furnace one giant crucible, hard, adapted to temperature changes and highly resistant to erosive action.

You should know all about what it saves in repairs, shutdowns and cost of relining. Write for our special bulletin. Consult us freely.

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This 20-page bulletin with valuable information on how to reduce lining costs and to repair old linings — sent free on request.

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"Q. R. GLASS" is made from highly refractory Pennsylvania fire clay, uniformly mixed, molded and fired. Free from shrinkage, pitting, spalling. Ideal for high temperature and sudden changes. Resists abrasion and friction.

Usually outlasts three ordinary fire brick installations. In a service test proved superior to nine other kinds. Excellent for wide and flat arches.

Difficult shapes our specialty. For setting, use our high-grade, finely ground fire clay. A complete line for all refractory purposes. Write to our free service engineering department.

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Double-Suspension Arch

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Interlocking Fire Brick Wall

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ADAMANT FIRE BRICK CEMENT

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Test it in your most severe service—use it whenever you use a fire brick, in drop forge and billet heating furnaces, soaking pits, retorts, generators, cupolas, boilers, etc.

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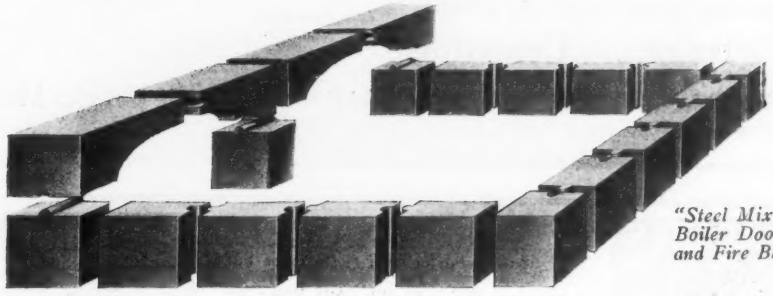
New York Office: 110 W. Thirty-fourth Street

Big Savings with "STEEL MIXTURE" Boiler Furnace Linings



"Steel Mixture" Boiler Door Arches and Fire Box Blocks.

ISN'T it obvious that one "Steel Mixture" Fire Box Block can be handled easier and in less time than the equivalent 9 to 39 fire bricks?

Isn't it obvious that tongued and grooved blocks can be laid more evenly, in less time, by less skilled labor, than ordinary fire bricks?

Isn't it obvious—because furnace linings deteriorate first at the joints—that "Steel Mixture" Blocks with only 1/6 to 1/3 as much joint surface next to the fire must last far longer than ordinary fire brick?

Isn't it obvious that we can make more durable refractories—with specialized equipment and nearly one hundred year's experience to guide us—than a power plant engineer can obtain with plastic materials which he must apply and harden under unfavorable conditions?

Isn't it obvious, therefore, that "Steel Mixture" Furnace Refractories are more economical than ordinary fire brick or plastic materials—that the use of "Steel Mixture" means fewer and shorter boiler shutdowns and less furnace expense?

Be Ready Next Time

Send for the "Steel Mixture" Bulletins now and be ready for your next relining job. Complete sets of "Steel Mixture" Fire Box Blocks and Boiler Door Arches for popular makes and sizes of boilers are carried in stock for immediate shipment. The setting for your particular boiler is factory-assembled, inspected, each block numbered, and shipped with key diagram for easy assembling.

Mail the Coupon for Free Bulletins

McLEOD & HENRY CO.

Specialists in furnace refractories for almost 100 years

Originators of STEEL MIXTURE Boiler Settings; Boiler-door Arches; Flat Suspended and Sprung Furnace Arches; Back-Combustion-Chamber Arches; Fire-box Lining; Boiler Baffle Tile; Blow-off Pipe Protectors; Standard and Special Fire Brick; Fire Cement and Fire Clay

Main Offices and Works, Troy, N. Y.

Branches in New York, Boston, Cleveland, and Detroit

STEEL MIXTURE
REG. U.S. PAT. OFF.

Every power plant man should know the savings effected by "Steel Mixture" products. Tear off the coupon now and mark the subjects that interest you. You'll find the Bulletins interesting as well as instructive.

McLeod & Henry Co., Troy, N. Y.
Please send Bulletins and information about STEEL MIXTURE for the following boilers.

Make ..... H. P. .....

☐ Complete boiler settings.
☐ Boiler-door arches and fire-box linings.
☐ Flat suspended furnace arches ☐ Sprung furnace arches.
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"Broadcasting Quality for 35 years"

Simplex — Duplex — Centrifugal

EVERY American-Marsh pump — whatever the type—has been sent out during the past thirty-five years on the "wave length" of QUALITY materials and workmanship. American-Marsh pumps are heavily constructed. Every pump is thoroughly tested before shipment. 195,000 in successful operation assure YOU of satisfactory service. We make such a variety of pumps that we suggest that you ask for bulletin covering just the type in which you are interested.

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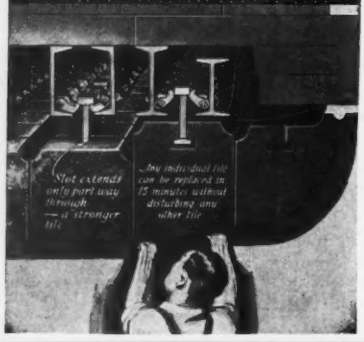
Chicago, 926 Monadnock Block New York, 17 Battery Place

NATIONAL ARCHES


Slot extends only part way through — a stronger tile
Any individual tile can be replaced in 15 minutes without disturbing any other tile

National Arches

A husky arch costs a little more but the extra cost is soon saved in maintenance cost and time out. Any tile, even the nose tile, can be replaced in fifteen minutes without disturbing any other tile or brick work.

National Stokers

The National Stoker has stationary grate bars with long travel pushers working between. The dump opening is the full width of the furnace. The easiest method of firing low grade fuels or wood refuse. High efficiency, smokeless operation and high overloads can be easily obtained.

THE M. A. HOFFT CO.

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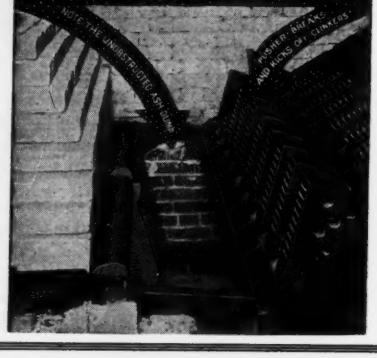
NATIONAL STOKERS



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Neemes Improved Shaking and Dumping Grates have for 50 years been the choice of careful and discriminating buyers because any kind of coal can be burned on them with the best possible combustion.

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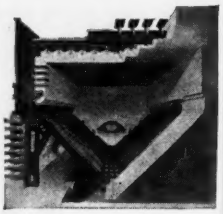
Manufacturers of Round and Square Grates
Established 1874

ECONOMY 1874 QUALITY NEEMES SERVICE

DETROIT "V" TYPE STOKERS



In one plant alone, Detroit V-Type Stokers save 5 tons of coal daily, and one man's labor. They will work proportionate savings for you.

Ask for Bulletin 324

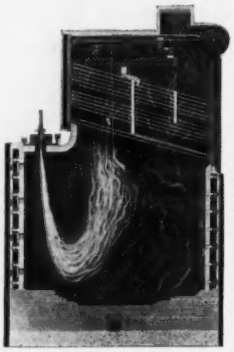
DETROIT STOKER COMPANY
324 General Motors Bldg.
DETROIT MICHIGAN

Fuller-Lehigh Pulverized Coal Equipment Stops Fuel Waste

Let our experienced engineers show how leading plants obtain practically perfect combustion of all coal grades.

Write for bulletin 900-E.

Fuller-Lehigh Company
Fullerton, Pa.



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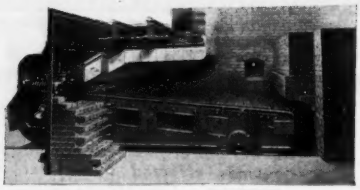
Noted for economy of installation, operation and maintenance. Write for full information to the Laclede Stoker Co., 4438 Hunt Ave., St. Louis, Mo.



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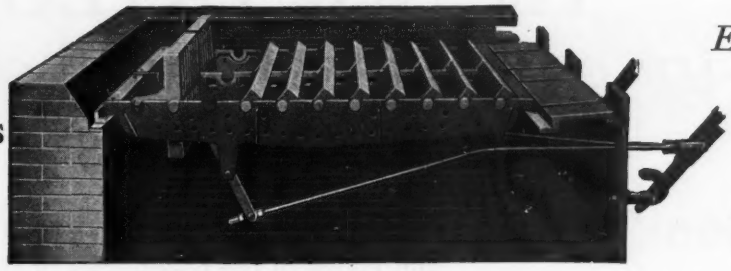
WHEN YOU BUY KELLY GRATES YOU BUY RESULTS



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Easy to Install

Burn the poorest grades marketed on **Kelly Rocking** and **Dumping Grates** and they do good work. All combustible in them is consumed before the residue reaches the pit. Steam loads are steadily maintained at the maximum.

Fuel beds on **Kelly Rocking** and **Dumping Grates** are liberally supplied with air. Grates are flat, and rocking keeps the fuel bed broken up so air enters every portion. **Clean combustion** results. **Fuel economy ranges from 10 to 25 per cent.**

Fire doors are opened on **Kelly Grates** only to supply fuel. All grate operation—cleaning, sifting, rocking, dumping, etc.—the fireman performs by the outside levers.

Kelly Grates are sturdily built of heat-resisting iron for durability. Backed by more than 35 years of grate building experience.

Write for our Catalogue "C" and fuller description of these famous grates.

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Established 1887 Power Plant Engineers

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The New TAYLOR gives the mechanical stoker a new status

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It's as far ahead of the mechanical stoker of yesterday as the modern automobile is ahead of the first benzene buggy.

When the Taylor Stoker can take coal right from the cars and burn it with an efficiency of over 92.7%, when it can make a boiler deliver an output averaging 528% of its rating, with a high mark of 603%—when it can reduce heat loss due to unconsumed combustible in the ash to as low as 4/10 of 1%—when it can produce such results without demanding of the operator anything more than intelligent supervision—it's time to bring your conception of the Taylor Stoker up to date.

The Taylor Stoker

the Simplest,
most Efficient,
most Economic
System of Combustion

You can do that very easily by just tearing off and mailing the coupon below—It will bring you a copy of our new Catalog that is written for the Executive as well as for the Engineer. It is fully illustrated.

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☐ Send the New Taylor Stoker Catalog.
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RILEY UNDERFEED STOKERS

MURPHY AUTOMATIC FURNACES

A Type for Every Stoker Need

Manufactured and sold by

The Sanford Riley Stoker Company

An organization with the personnel and equipment to solve your combustion problems

Our representatives located in the district offices are first-of-all engineers, men who know the practical and theoretical side of combustion.

The engineering department has at its disposal the accumulated experience of over 40 years in this one field. The Murphy is the pioneer overfeed stoker while the Jones was the originator of the underfeed type. Since the days of Thomas Murphy and Evan Jones developments have been carried on ceaselessly to make each of our products give every user the utmost in efficiency, economy and dependability.

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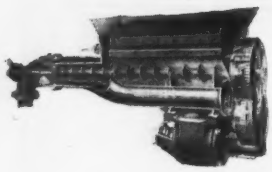

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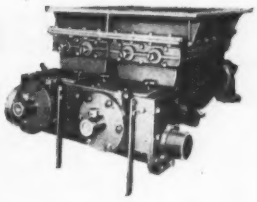
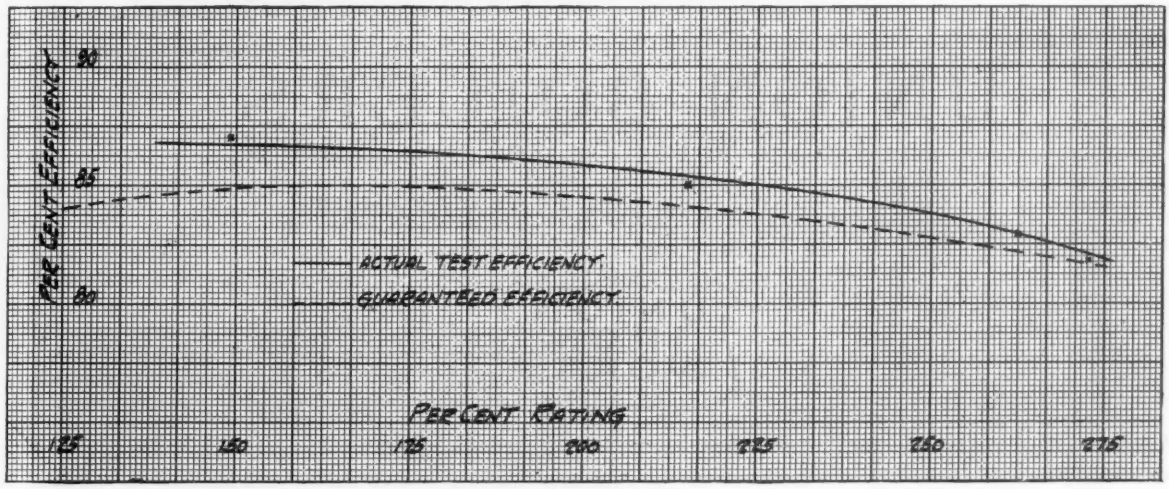


Lopulco Pulverized Fuel Performance



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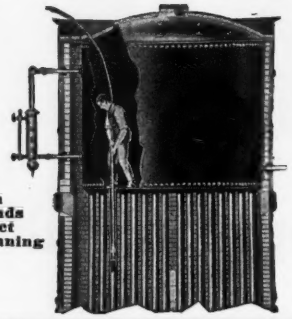
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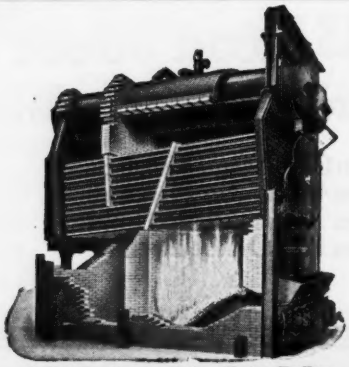
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SALT, soap or steel—candy, cement or central stations—in practically every important industry where steam is used for power or process, Edge Moor Boilers are to be found in the service of the representative leaders.

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Established 1868
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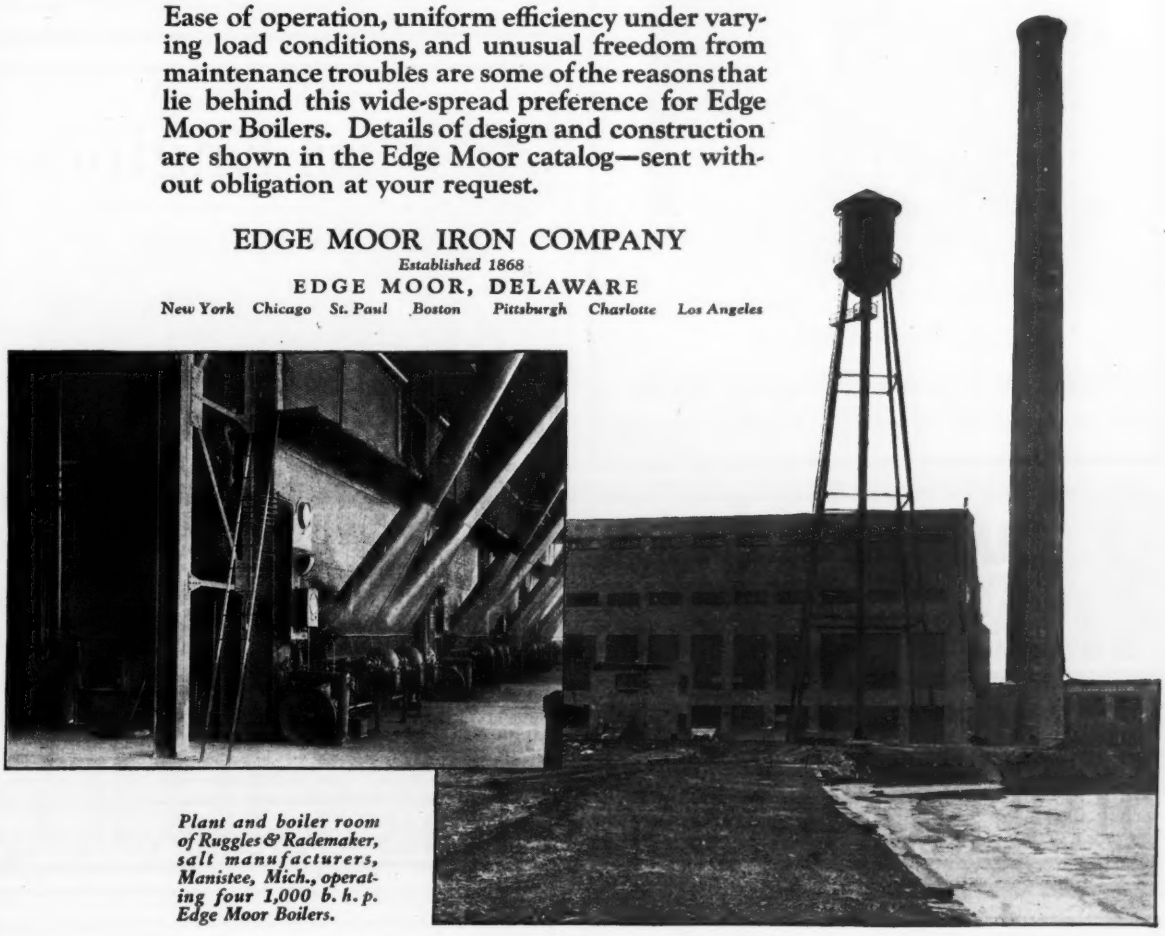

Plant and boiler room of Ruggles & Rademaker, salt manufacturers, Manistee, Mich., operating four 1,000 b. h. p. Edge Moor Boilers.

EDGE MOOR Water Tube BOILERS

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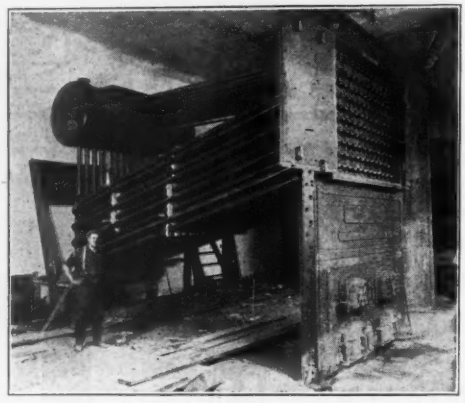
FOR INCREASED FUEL ECONOMY

Kingsford-Webster Sectional Water Tube Boilers

All steel construction.
Built in all H. P. sizes for all pressures.



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Corliss Engines
for belted or direct connected service
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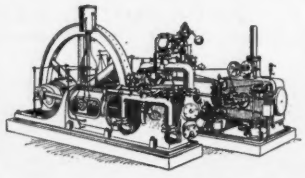

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Established 1867
Chicago Office
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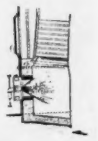

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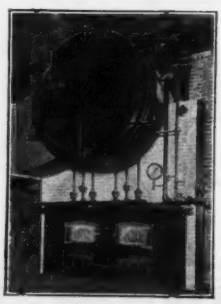

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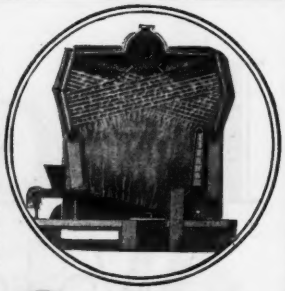

Page Water-Tube Boilers

PPE-R-RTG

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IT costs a great deal of time and money to true up a commutator or slip ring that is worn and pitted, when you use the old methods, while the occasional application of an Ideal Commutator Resurfacer will keep them in excellent condition always. Made in grades and shapes to suit all conditions and types of equipment. Applied under full load. Can't transmit a shock nor cause a "short." Last a surprising length of time. Ask for free trial. Give approx. R. P. M., dia. and width of comm. or ring, distance between brush sets, condition and commutator material.

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Carbon Brushes

are Self-Lubricating

They last longer and serve better than ordinary brushes.

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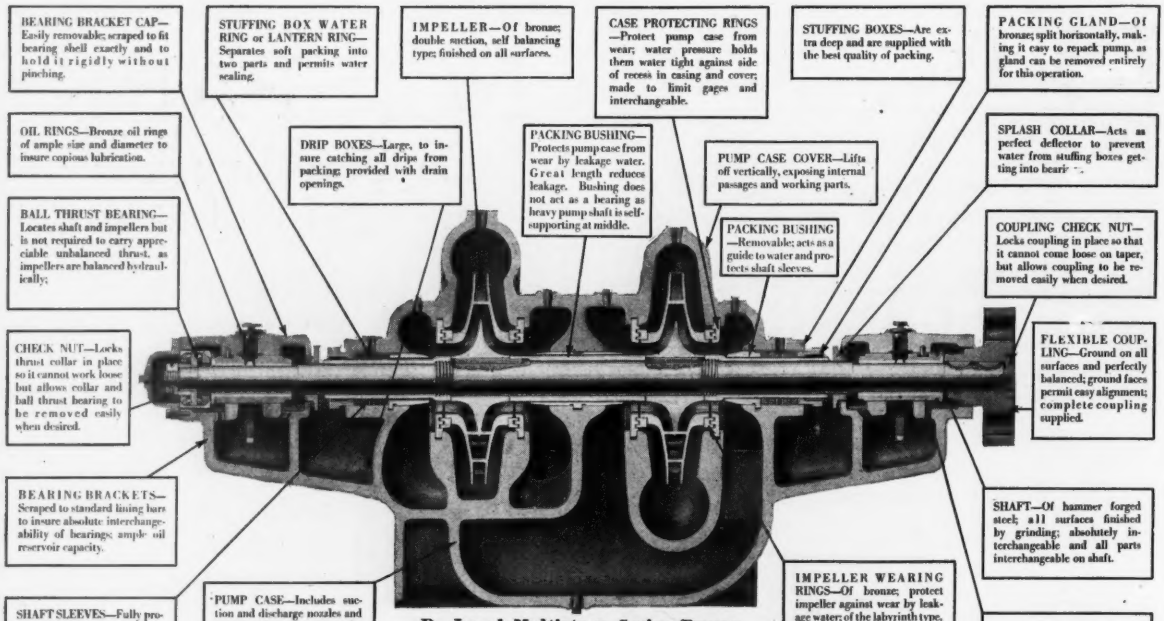
More than 9000 Terry Turbines now in operation. There is a type to meet your particular needs. Terry engineers are available for consultation and advice on any problem involving the use of a turbine. Write for information, stating your steam conditions and power requirements.

The Terry Steam Turbine Co.

Hartford, Conn.


BEARING BRACKET CAP—Easily removable; scraped to fit bearing shell exactly and to hold it rigidly without pinching.
STUFFING BOX WATER RING or LANTERN RING—Separates soft packing into two parts and permits water sealing.
IMPELLER—Of bronze; double suction, self balancing type; finished on all surfaces.
CASE PROTECTING RINGS—Protect pump case from wear; water pressure holds them water tight against side of recess in casing and cover; made to limit gages and interchangeable.
STUFFING BOXES—Are extra deep and are supplied with the best quality of packing.
PACKING GLAND—Of bronze; split horizontally, making it easy to repack pump, as gland can be removed entirely for this operation.
OIL RINGS—Bronze oil rings of ample size and diameter to insure copious lubrication.
DRIP BOXES—Large, to insure catching all drips from packing; provided with drain openings.
PACKING BUSHING—Protects pump case from wear by leakage water. Great length reduces leakage. Bushing does not act as a bearing as heavy pump shaft is self-supporting at middle.
PUMP CASE COVER—Lifts off vertically, exposing internal passages and working parts.
SPLASH COLLAR—Acts as perfect deflector to prevent water from stuffing boxes getting into bearings.
BALL THRUST BEARING—Locates shaft and impellers but is not required to carry appreciable unbalanced thrust, as impellers are balanced hydraulically;
PACKING BUSHING—Removable; acts as a guide to water and protects shaft sleeves.
COUPLING CHECK NUT—Locks coupling in place so that it cannot come loose on taper, but allows coupling to be removed easily when desired.
CHECK NUT—Locks thrust collar in place so it cannot work loose but allows collar and ball thrust bearing to be removed easily when desired.
FLEXIBLE COUPLING—Ground on all surfaces and perfectly balanced; ground faces permit easy alignment; complete coupling supplied.
BEARING BRACKETS—Scraped to standard lining bars to insure absolute interchangeability of bearings; ample oil reservoir capacity.
SHAFT—Of hammer forged steel; all surfaces finished by grinding; absolutely interchangeable and all parts interchangeable on shaft.
SHAFT SLEEVES—Fully protect the shaft from contact with liquids pumped and from wear by the packing; threaded on shaft, one with right hand thread and the other with left hand thread; the middle sleeve acts as a spacer for impellers and is held by pump wheel key.
PUMP CASE—Includes suction and discharge nozzles and passages from one stage to the next; cast in dry sand molds to insure accuracy of form and smooth finish; shape of walls gives great strength; machined to limit gages to insure perfect fit of internal parts and to secure interchangeability.
IMPELLER WEARING RINGS—Of bronze; protect impeller against wear by leakage water; of the labyrinth type, permitting of running with greater clearances than are permissible with flat wearing rings, while allowing less leakage and wearing longer; threaded onto impeller, not shrunk on or held by rivets, hence easily removable.
BEARINGS—Only high grade babbitt used and bearings machined and ground with great accuracy, so that they are interchangeable; bearing pressure extremely low, to insure long life of bearing.

De Laval Multistage Series Pumps

A multistage pump in which the advantages of double suction impellers and volute diffusers are combined.

The casing is split horizontally on a plane passing through the center line of the shaft. All interior parts are accessible on removing the casing cover and without disconnecting piping. All parts are made to limit gages and are interchangeable. Capacity, efficiency and other characteristics are guaranteed and each pump is tested before leaving the works. Ask for Catalog H-50.

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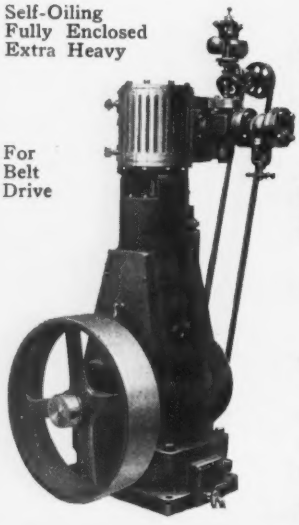
TROY ENGINE

successfully utilizes modern temperatures and pressures

Self-Oiling
Fully Enclosed
Extra Heavy

For Belt Drive



Furnished with a correct and dependable lubricating system that assures safe and smooth operation even at extreme speeds.

Adapted to a great variety of purposes. Minimum number of parts that need possible replacement.

Sizes 5 to 40 hp. now ready.

Send for Bulletin H.

Troy Engine & Machine Co.
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Riley Engineering Co., of Canada, Ltd., 146 King Street West, Toronto, Can.

"Only Steam Engines—Good Engines Only"

The Ridgway Organization

Executives, Engineering and Sales Department, District Sales Managers, Road Men and Factory Employees,

Unite in thanking you

for the measure of Prosperity accorded them during the Past Year,

and in wishing you

Prosperity and Happiness for Nineteen Twenty-Five.

RIDGWAY DYNAMO & ENGINE CO.
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STEAM TURBINES
CENTRIFUGAL PUMPS
REDUCTION GEARS

MOORE STEAM TURBINE CORPORATION
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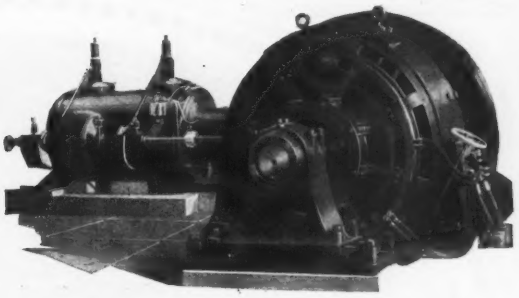
"BEST AT EVERY TURN"

LENTZ Engines Cut Power Costs



ECONOMY at all loads with the highest operating efficiency are positive results Lentz Engines give.

Every detail in their construction is an asset to their economy. There are no unnecessary parts.

Weight and space correspond to modern plant requirements.

Vibration is minimized. Highest safe speeds. Poppet Valves **always tight.**

Ideal for use with saturated or superheated steam for either condensing or non-condensing operation.

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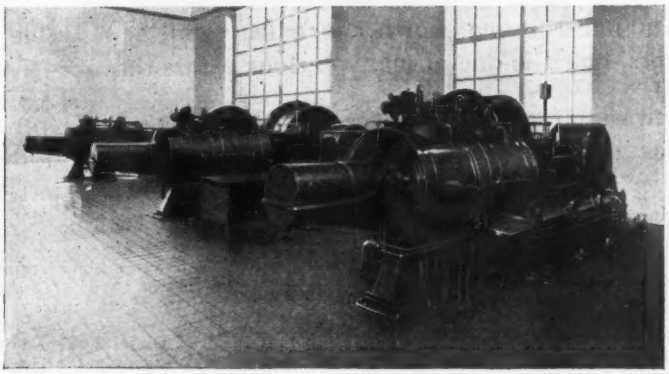
1510 EAST AVE. ERIE. PA.
Founded in 1840

Makers of Vertical, Horizontal and Inclined Water Tube Boilers, Horizontal Tubular and "Economic" Boilers, Pulverized Coal Equipment and Lentz Engines, Tanks and Steel Plate Work.
Sales Engineers in the Principal Power Centers of the World

The "Universal Unaflow"



The Most Economical Steam Engine Ever Built

If we had not guaranteed to the owner of the above plant that it was cheaper to generate current with "Universal Unaflow" engines than to purchase cheap central station current, this plant would not have been installed.

The engines in service substantiated our guarantee. The original installation consisted of two engines, the third being purchased after one year's operation.

Central station current could have been purchased for $.017 per kilowatt-hour.

Built only by

Skinner Engine Company, Erie, Pa.

Branch Offices in all principal Cities

A plant like the one shown above may not be suitable for your requirements, but it is one of many various plants that we have built up.

We can supply engines in sizes from 20 to 8,000 H. P. for all classes of purposes and can give results comparable with any other form of prime mover as is shown by the following extract of a letter recently received, facsimile of which will be sent upon application.

"The record of the McIntosh & Seymour engine is an agreeable surprise to our board, as it shows that we are producing one KWH at a cost of about 1/10 of a gallon of fuel oil, which averages in cost for the year 6 cents a gallon in our tanks.

"It has been demonstrated beyond question that the true Diesel Type Engine is the most economical unit for the production of electricity, excepting only the larger hydro-electric and larger steam turbine plants."

Write us for further particulars of our product. We can save you real money.

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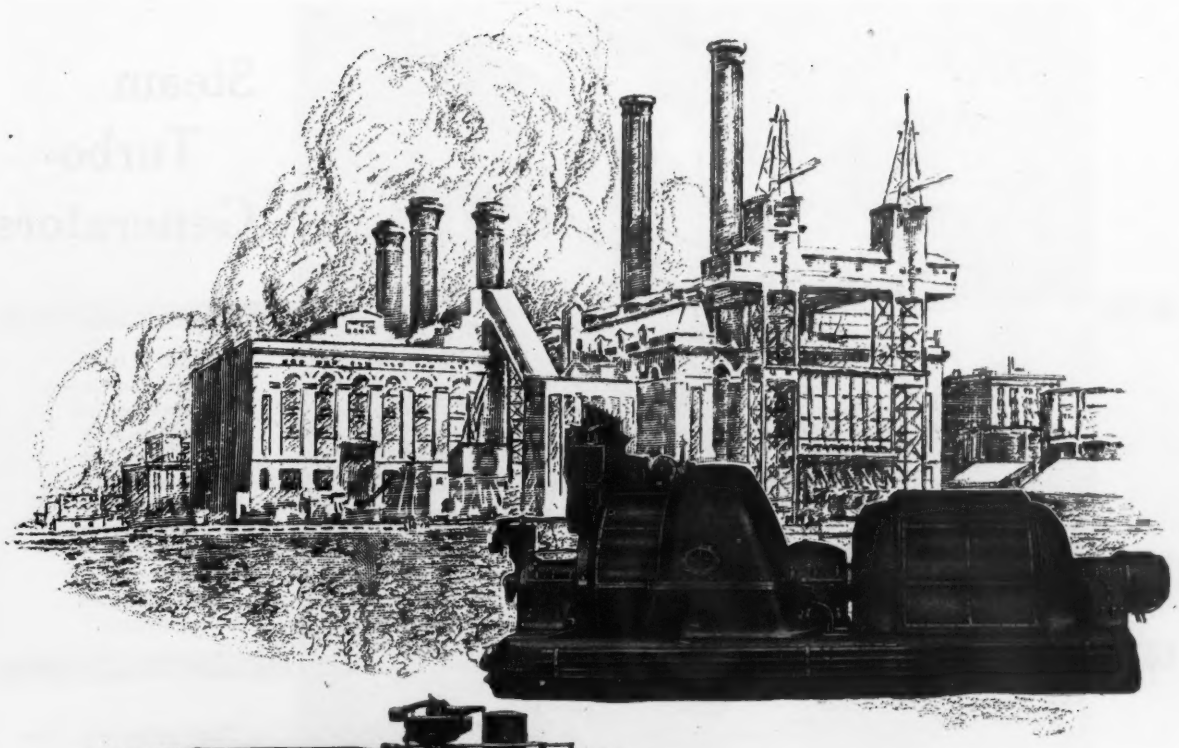

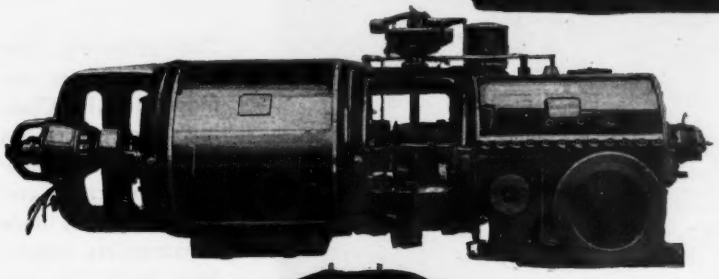

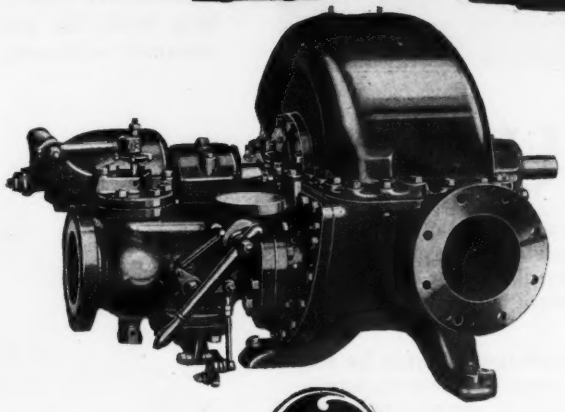

Your plant stands where in *economy*?

World standards in generating economies have been established by several of America's largest generating stations

—equipped with G-E Turbines.

The same high standards in plant performance are attainable by the smaller stations and industrial plants

—through G-E Small Turbines.

Large or small, G-E Turbines are characterized by exactly the same principles and high qualities. Specify them for driving your auxiliaries also.

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Schenectady, N. Y.
Sales Offices in all Large Cities

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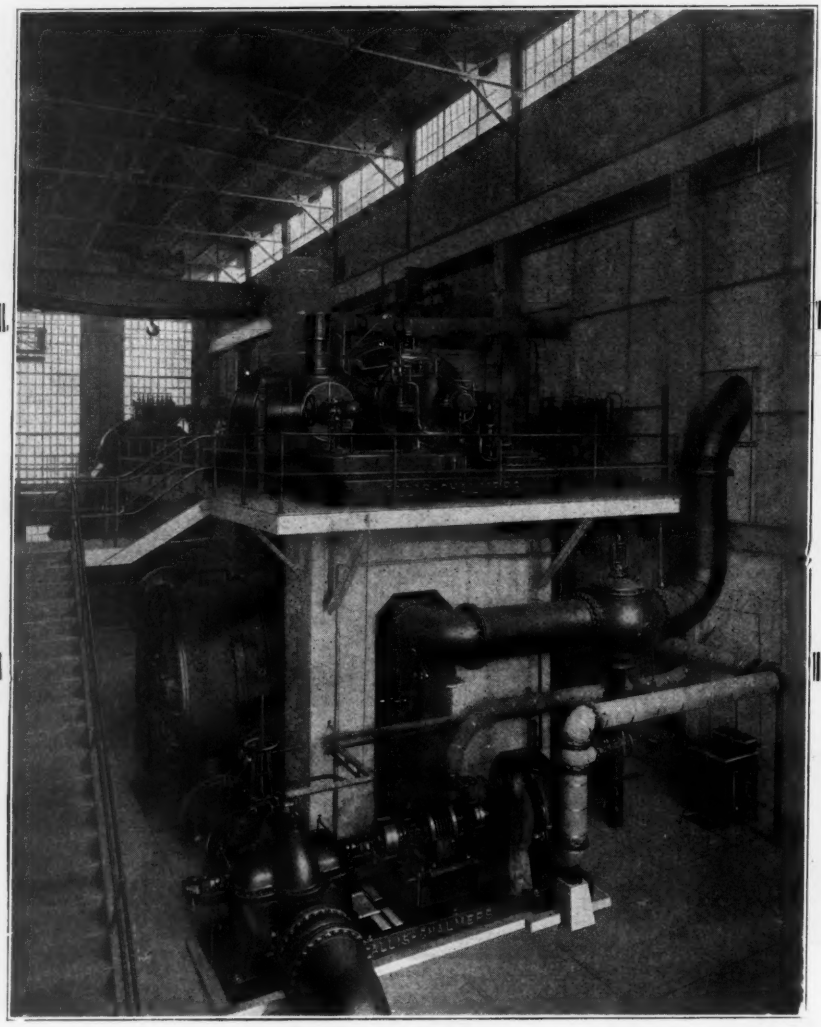
GENERAL ELECTRIC



Steam Turbo-Generators

12,500 K.W. Steam Turbine Generator Unit complete with Surface Condenser, Turbine-driven Circulating and Condensate Pumps, all of Allis-Chalmers manufacture.

The relatively low steam velocities employed in Allis-Chalmers Steam Turbines combined with low blade velocities and highest type of blade construction insures long blade life and sustained efficiency.

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Many public service companies testify to the advantages and appreciable savings under the Allis-Chalmers plan of "Undivided Responsibility," where the manufacturer assumes complete responsibility for the design, building and placing in operation of the principal equipment for the power plant.

Complete equipment "from prime mover to switchboard" is built by the Allis-Chalmers organization. This includes all types of prime movers—steam turbines, hydraulic turbines, steam, gas and oil engines, together with complete electrical equipment. Condensers of all types, pumps, air compressors and many other auxiliaries are also supplied. Allis-Chalmers equipment is used in plants of all sizes, and includes some of the largest power units ever built.

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Agricultural Machinery
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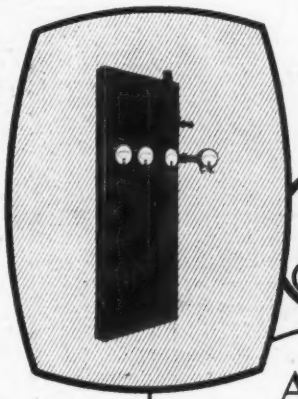

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WESTINGHOUSE ELECTRIC

About Switchboards

WHEREVER electricity is used, some kind of switching equipment for controlling it, is necessary. Even in the steam power plant, there often arises need for a switchboard. Westinghouse makes switchboards to fill the needs of each particular installation, from the smallest panelboards to huge switchboards.

Consult Westinghouse with your switchboard problems.

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East Pittsburgh Pennsylvania
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